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A Cost, Cost/Effectiveness Comparison Between the Use of Enclosures vs. Quiet Machines as Noise Reduction Options for the Fabricated Metal Products Industry

IIT Research Institute, Chicago, Illinois

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A COST, COST/EFFECTIVENESS COMPARISON BETWEEN THE USE OF ENCLOSURES VS. QUIET MACHINES AS NOISE REDUCTION OPTIONS FOR THE FABRICATED METAL PRODUCTS INDUSTRY

Task Report J6331

by

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This is a task report of effort directed toward a pilot study on one noise intensive industry (the fabricated metal products industry) to more clearly define the machinery noise problem of that industry, the technology available to reduce the machine noise levels, the technology that needs to be developed and the most cost/effective/beneficial means of providing federal research, development and demonstration participation. Specifically, this task was directed toward exploring the cost and cost/effectiveness trades relating to the options of adding enclosures to machines or buying quiet machines.

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ABSTRACT

This is a task report of effort directed toward a pilot study on one noise intensive industry (the fabricated metal products industry) to more clearly define the machinery noise problem of that industry, the technology available to reduce the machine noise levels, the technology that needs to be developed and the most cost/effective/beneficial means of providing federal research, development and demonstration participation. Specifically, this task was directed toward exploring the cost and cost/effectiveness trades relating to the options of adding enclosures to machines or buying quiet machines.

Accomplishments include: enclosure sizes and costs were estimated for 443 machines and distributed over the 160 machine types, 31 machine classes and five machine groups of the fabricated metal products industry; incremental machine costs and productivity losses were estimated for 160 machine types and distributed over the 31 machine classes and five machine groups of the industry; and cost and cost/effectiveness analyses were conducted for the options of using enclosures to reduce machine noise levels, or purchasing quiet machines as replacements.

The findings of this study include: in comparing the incremental cost of buying quiet machines versus enclosing the machines, the average incremental machine costs are consistently below enclosure costs. On an industry wide basis the total cost to the industry is about 5.2 billion dollars less if the quiet machinery option is selected.

This report is submitted in partial fulfillment of project number J6331, Contract Number 68-01-2234, by IIT Research Institute, under sponsorship of the Environmental Protection Agency. Work on this task was completed as of December 1975.

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SECTION I

CONCLUSIONS

The conclusions of this study are summarized in four sections.

ENCLOSURES VS. INCREMENTAL COSTS OF BUYING QUIET MACHINES

In comparing the incremental cost* of buying quiet machines versus enclosing the machines the average incremental machine costs are consistently below enclosure costs. On an industry wide basis the total cost to the industry is about 5.2 billion dollars less if: 1) all of the machines in the industry with noise levels above 85 dBA are treated; 2) all of the machines are either enclosed or quiet machines are purchased; and 3) the quiet machinery option is selected.

Confounding factors which relate to the quiet machinery option on an individual machine purchase basis include:

- The life cycle status of the machine such that a new machine may not be warranted. In this case the cost of the new machine plus the incremental cost must be considered and evaluated against the option of enclosing the current machine.
- The quiet machine may not be available on the market.
- A quiet process may be substituted for a noisy process to achieve a least cost solution.

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*The incremental cost is the increase in capital equipment cost associated with implementing noise reduction technology on a particular machine type (e.g. lathe), machine class (e.g. turning machines) or machine group (e.g. metal cutting machines).

The comparison does, however, indicate that there is a significant long term economic payoff in developing quiet machines to reduce the noise exposure levels of the machine operators.

ENCLOSURES

The analysis of the use of enclosures as a noise control option indicates:

- Somewhat over 12.2 billion dollars would need to be spent to enclose every machine in the industry.
- The average enclosure cost per machine is about $3,400.
- The average enclosure cost per machine operator is about $24,400. (There are significantly fewer machine operators than machines.)
- If the machines are treated in accordance with their noise level rank the average noise level of the industry vs. the cost of enclosing the machines are as follows:

Average Noise Level of Industry (dBA)	Expenditure on Enclosures (Billions of Dollars)	Reduction in Exposed Operators (Thousands)
100	3.1	125
95	7.5	325
90	11.2	505
85	12.2	510
80	12.6	511

QUIET MACHINES

The analysis of the use of quiet machines as a noise control option indicates:

- About 7.0 billion dollars would need to be spent by industry as a noise related machine cost.
- The average A machine cost for the industry is about $1,900.
- The cost of protecting each machine operator to a level of 85 dBA is approximately $13,900 for industry wide protection.

- If the noisest machines are treated in accordance with their noise level rank the average noise level of the industry vs. the incremental machinery costs are as follows:

Average Noise Level of Industry (dBA)	Expenditure on Enclosures (Billions of Dollars)	Reduction in Exposed Operators (Thousands)
100	1.5	125
95	3.5	325
90	6.2	505
85	7.0	510
80	7.1	511

PRODUCTIVITY LOSS

There is insufficient and conflicting data on productivity loss due to adding enclosures. Losses as high as 30 percent and increases as high as 11 percent have been cited. Productivity losses have been estimated more explicitly, but perhaps not more accurately, for the quiet machines. Those estimates indicate an average productivity loss for the industry in the order of 9 percent. Most of the productivity loss data were gathered shortly after the machines were modified. During this period the manufacturing processes which were used prior to the modification were either not modified or modified only slightly to accommodate the machinery or equipment change. It appears reasonable to expect that many of the productivity losses cited can be negated by process optimization. However, it is also reasonable to expect that in the instances in which the process has been optimized prior to effecting a change to a machine a productivity loss can be expected.

SECTION II

INTRODUCTION

This is a task report of effort directed toward a pilot study on one noise intensive industry (the fabricated metal products industry) to more clearly define the machinery noise problem of that industry, the technology available to reduce the machine noise levels, the technology that needs to be developed and the most cost/effective/beneficial means of providing federal research, development and demonstration participation. Specifically, this task was directed toward exploring the cost and cost/effectiveness trades relating to the options of adding enclosures to machines or buying quiet machines.

The objectives of this effort were to:

- Estimate costs of implementing existing and potential noise reduction technologies. The machines, the applicable noise reduction techniques and the required levels of noise reduction were to be examined and an estimate made as to the approximate cost to reduce the machine noise levels.

- Conduct a cost, cost/effectiveness analysis that considered:

  Cost to reduce noise levels to various levels.

  A productivity.

  A capital investment.

  Number of operators exposed.

  Number of machines quieted.

  Mean noise levels of machines in the industry.

The tasks relating to this objective were completed and are summarized in this document. Accomplishments of this study include:

- Enclosure sizes and costs were estimated for 443 machines and distributed over the 160 machine types, 31 machine classes and 5 machine groups of the fabricated metal products industry.

- Incremental machine costs and productivity losses were estimated for 160 machine types and distributed over the 31 machine classes and five machine groups of the industry.

- Cost and cost/effectiveness analyses were conducted for the options of using enclosures to reduce machine noise levels or purchasing quiet machines as replacements for noisy machines.

The enclosure sizes and the enclosure and incremental machine cost data are compiled in Appendix A (enclosure data) and Appendix B (machine cost data). Since these data are not readily available in any of the literature or data files reviewed it was felt that these appendicies would serve as a useful file.

The remaining sections of this report provide material and analyses of enclosures and quiet machines as potential options of reducing the noise level of the industry. The sections of the report of each option are very similar in content structure. This method of presentation was chosen to provide a convenient means for a one-to-one comparison between the two options.

SECTION III

COSTS OF MACHINERY ENCLOSURES

OVERVIEW

Metal cutting and forming machines come in a wide variety of sizes and shapes. This distribution makes it difficult to generate "average" numbers for the industry either on cost or the size of enclosures. Conversely, there is a need to estimate cost and size data which are representative to serve as bases for any industry wide cost/effectiveness analysis or for an analysis relative to the industry's ability to pay for adding the enclosures. Pursuant to this it became evident that a thorough survey of the machines in the industry would led to a significant expense since the machines are distributed over 27,000 companies. On the other hand a minor survey has a tendency to impose a bias unless a truly representative sample is selected. As a compromise a survey of machinery manufacturers catalogs (references 1 and 2) and selected textbooks (References 3 through 6) was conducted to provide sample machine sizes. These data were distributed throughout the machines according to the breakdown provided in the American Machinist Inventory (Reference 8). In many instances machinery dimensions were given directly. However, in the instances where dimensions were missing drawings and photographs were scaled.

Enclosure sizes were then estimated for each machine for which size data was available. Enclosure costs were estimated on the basis of $6/sq ft of surface area (Reference 7). Machines, enclosures and costs were then aggregated and averaged as required. Averages were calculated by weighting the individual values by the number of machines or the number of machine operators (as appropriate).

MACHINE AND ENCLOSURE DIMENSIONS

The primary sources of data for machinery dimensions are SWEET's Manufacturing Engineering Catalog File (Reference 1) and SWEET's Manufacturing File (Reference 2). These two sources contained about 80 percent of the data compiled. Text books (References 3 through 6) represented about 20 percent of the data.

Enclosure dimensions were estimated by adding three feet to each length, width and height dimension, except that the minimum height is eight feet.

The table of machine dimensions and enclosure surface areas is included as Table A-1 of Appendix A. Dimensions which were estimated are denoted by the "E" after the number.

ENCLOSURE COSTS

Enclosure costs, mean machine noise level, enclosure surface area, and number of machines in the industry, as compiled for each machine type (e.g. bench lathes) and for each machine class (e.g. turning machines), are given in Table A-2 of Appendix A.

The average enclosure cost for the machine class is calculated as a weighted average of the enclosure costs of the machine types.

SUMMARY OF ENCLOSURE COSTS, NOISE LEVELS AND NUMBERS OF MACHINES AND OPERATORS

Table 1 is a summary compilation of Table A-2 of Appendix A. The column listing the number of machine operators for each machine class (Reference 9) is added for completeness. An inspection of this table indicates:

- Somewhat over 12.6 billion dollars would need to be spent to enclose every machine in the industry;
- Average enclosure costs for the machine class vary from a low of $1,100 for polishing and buffing machines to a high of $33,900 for enclosures for planning machines;
- The average enclosure cost for the industry ($12.6 billion divided by 3.7 million machines) is about $3,400;

Table 1. ENCLOSURE COSTS, NOISE LEVELS, NUMBERS OF MACHINE AND OPERATORS

Machine Class	Average Enclosure Cost ($)	Total Enclosure Cost for Machine Class (Millions of Dollars)	Number of Machines in Class	Class Machine Noise Level (dBA)	Number of Machine Operators (1978)
Turning Machines	3,000	1,677	483,677	91	81,378
Boring Machines	4,700	337	94,166	94	1,958
Drilling Machines	2,000	1,921	433,715	93	61,554
Milling Machines	3,000	1,133	288,139	96[a]	13,997
Multifunction Machines	5,000	74	14,738	96[a]	1,309
Special Way and Transfer Machines	15,300	198	14,894	96[a]	843
Automatic Assembly, Tapping and Threading Machines	4,300	391	89,375	93	8,513
Broaching Machines	2,000	96	14,030	91[a]	760
Planning Machines	33,900	238	7,013	110	373
Shaping Machines	2,300	71	28,343	99[a]	2,041
Cutoff, Sawing and Filing Machines	3,000	683	218,901	106	17,460
Grinding Machines	2,600	1,399	499,600	93	43,293
Honing Machines	2,100	63	30,793	93[a]	806
Lapping Machines	2,000	30	13,330	93[a]	434
Polishing and Buffing Machines	1,100	238	110,216	93	9,313
Gear Cutting & Finishing Machines	3,100	139	41,387	84	368
Electrical Machining Units	2,300	26	11,176	83[a]	331
Other Metal Cutting Machines	3,000	47	13,669	93[a]	533
Bending and Forming Machines - Power	8,000	793	98,311	103	33,733
Hydraulic and Pneumatic Presses	3,900	301	76,799	1013	3,994
Mechanical Presses - Power	4,600	1,339	290,979	998	103,813
Punching and Shearing Machines - Power	3,700	337	99,038	103	33,330
Forging Machines	9,300	638	37,767	108	9,936
Wire and Metal Ribbon Formers	5,600	153	30,313	98	3,356
Riveting Machines	1,900	109	59,331	116	9,136
Other Metal Forming Machines	2,900	113	38,767	89	4,490
Electric Arcwelding Equipment	1,600	590	363,030	97	71,963
Electric Resistance Welding Equipment	6,700	678	103,956	96[a]	33,633
Other Joining Equipment	3,600	113	31,030	97	3,071
Die-casting Machines	9,300	61	11,319	80	973
Cleaning and Finishing Equipment	7,300	1,093	146,013	101	34,961
	TOTALS	12,630	3,730,764	--	511,501

[a] E = Estimated Machine Class Mean Noise Level.

- 49 percent of the enclosure costs are distributed over five machine classes; turning machines, mechanical presses, grinding machines, milling machines and cleaning and finishing equipment;
- 74 percent of the enclosure costs are distributed over 10 machine classes; and
- The remaining 26 percent of the enclosure costs are distributed over 21 machine classes.

SECTION IV

COST/EFFECTIVENESS OF ENCLOSURES

ENCLOSURE EXPENDITURE VS. MAXIMUM TYPICAL NOISE LEVEL FOR INDUSTRY

Enclosure cost data for a machine class (column 3 of Table 1) can be combined with the mean machine noise level (column 5 of Table 1) to illustrate the expenditures on enclosures as a function of the noise reduction. If the noisiest machine class is treated first and then each subsequent noisiest machine class is treated, the cost of enclosures as a function of the maximum typical noise level for the industry relationship is generated. This relationship is shown in Figure 1.

This figure illustrates the following:

- The cost-noise level relationship is an "S"-shaped curve whereby the most cost/effective zones are at the low and high ends of the curve. This results from 78 percent of the machines having noise levels in between 90 and 100 dBA.
- A cost/AdBA = $.2 billion/dBA from 110 to 100 dBA
- A cost/AdBA = $.8 billion/dBA from 100 to 90 dBA
- A cost/AdBA = $.1 billion/dBA from 90 to 80 dBA
- Reducing the maximum noise level of the industry to 100 dBA requires an expenditure for enclosures of 3.1 billion dollars.
- Reducing the maximum noise level of the industry to 95 dBA requires an expenditure of 7.3 billion dollars.
- Reducing the maximum noise level to 90 dBA requires 11.3 billion dollars.
- Reducing the maximum noise level to 85 dBA requires 12.3 billion dollars.

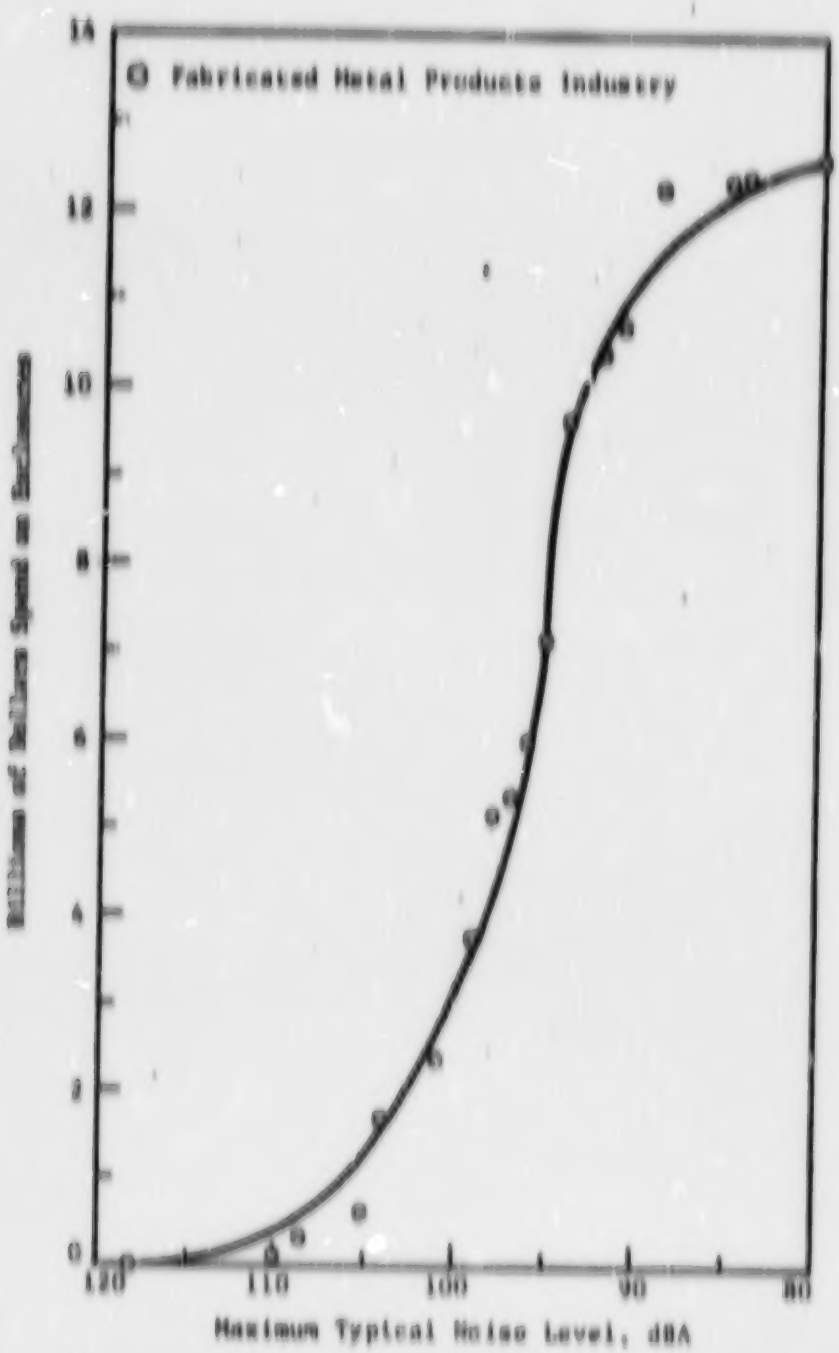

Figure 1. Enclosure Expenditure Vs. Maximum Typical Noise Level for Industry.

- Reducing the maximum noise level to 80 dBA requires 12.6 billion dollars.

ENCLOSURE EXPENDITURE VS. REDUCTION IN THE NUMBER OF OPERATORS EXPOSED

Data from columns 3, 5 and 6 of Table 1 can be combined to develop the relationship between the cost of enclosures and the reduction in the number of machine operators exposed. This relationship is shown in Figure 2. The calculated data points, as derived from the table, are shown as well as the maximum typical noise level for the industry resulting from the expenditure. As with the generation of Figure 1, the machine classes are assumed to be treated according to their noise level rank - the loudest first, etc. A review of the figure indicates:

- The expenditure - exposure relationship is approximately linear. The cost/effectiveness of enclosures - on a number of machine operators exposed basis - is approximately constant.
- The average cost of protecting each machine operator is approximately $24,400[a] for industry wide protection to 85 dBA.
- The average cost per operator is approximately $24,400 for industry wide protection to 90 dBA.
- The average cost per operator is approximately $21,900 for industry wide protection to 95 dBA.
- The average cost per operator is approximately $30,100 for industry wide protection to 100 dBA.
- The average cost per operator is approximately $31,800 for industry wide protection to 105 dBA.

[a] These average costs are significantly higher than average costs of enclosures because all of the machines in a class are assumed to be enclosed but any individual machine may not necessarily be utilized 100 percent of the time.

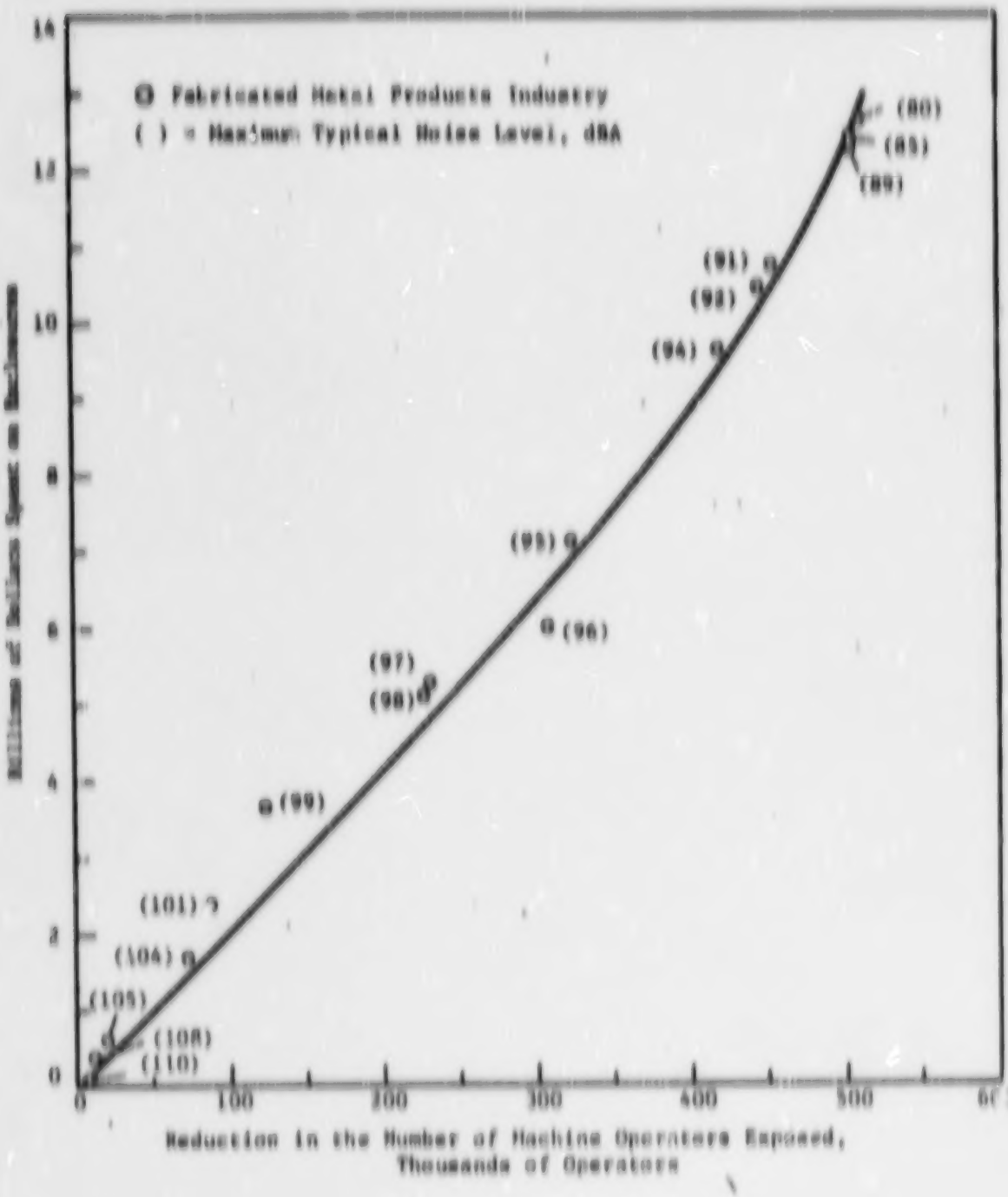

Figure 2. Enclosure Expenditure Vs. Reduction in the Number of Machine Operators Exposed.

ENCLOSURE COST SUMMARY

Table 3 is a summary compilation of enclosure costs for the industry. These costs are distributed over the machine groups (e.g. metal cutting machines, metal forming machines, etc.). All "average" values presented in the table represent weighted averages which were derived from the data in Table 1.

Based on this table the following are noted:

- Enclosures for the industry:

  The average enclosure cost/effectiveness ratio, which is a measure of how efficiently enclosures "quiet machines," is $308/dBA.

  The average enclosure cost per operator is approximately seven times the average enclosure cost per machine. This is a direct result of the surplus of machines over machine operators.

  If only those machines to which operators are assigned could be enclosed the total enclosure cost to the industry would drop from 12.6 billion dollars to a value closer to 1.7 billion dollars (average enclosure cost per machine x number of machine operators). This lower limit of enclosure costs is unattainable because the idle machines are not truly idle throughout any extended period of time. The true cost to the industry will, most likely, be closer to the upper value of 12.6 billion dollars. Manufacturers would tend to first enclose those machines most closely connected to their high volume production and add enclosures to the other machines as required for the production of their full product line. Some machines, however, may never be enclosed if their daily duty cycle is within the bounds allowable by the noise level-exposure time standard.

- Metal cutting machine enclosures:

  Represent 31 percent of the industry enclosure costs.

  The average enclosure cost/effectiveness ratio is $325/dBA.

  The average enclosure cost per machine, for the group, ($3,038) is near the average cost per machine for the industry ($3,400). The average enclosure cost per machine operator ($36,958) is somewhat above the industry average

Table 2. [illegible]

Machine Group	Total Exclusive Cost for Machine Group (Billions of Dollars)	Number of Machines in Group	Mean Group Noise Level (dBA)	Number of Machine Operators (1972)	Average Exclusive Cost per Operator ($)	Average Exclusive Cost per Machine ($)	Average Exclusive Cost/ Effectiveness Ratio ($/dBA) for 85 dBA
Metal Cutting Machines	7,177	2,362,233	95	154,195	36,958	3,038	325
Metal Forming Machines	3,379	703,357	102	38,887	18,586	4,805	339
Joining Equipment	981	496,882	96	99,480	9,861	1,975	178
Excavating Equipment	61	11,229	88	975	62,564	5,437	0
Cleaning and Finishing Equipment	1,052	146,813	101	34,841	30,194	7,165	459
TOTAL	12,650	3,720,364	97 (average)	331,387	34,731 (average)	3,458 (average)	356 (average)

($34,731). This trend is representative of the use of metal cutting machines whereby many of the machine types have relatively low utilization rates.

- Metal forming machine enclosures:

  Represent 37 percent of the industry enclosure costs.

  The average enclosure cost/effectiveness ratio is $319/dBA.

  The average enclosure cost per machine, for the group, ($4,805) is above the average for this industry. The average enclosure cost per machine operator is slightly below the average for the industry. This latter trend is typical of high utilization and high production rate machines.

- Joining equipment enclosures:

  Represent eight percent of the industry enclosure costs.

  The average cost/effectiveness ratio is $178/dBA this represents a relatively high level of noise reduction efficiency and it is the lowest cost/effectiveness ratio in the industry.

  Both the average enclosure cost per machine ($1,970) and the average enclosure cost per machine operator ($9,841) are significantly below the respective averages for the industry.

- Die casting equipment enclosures:

  Represent less than one percent of the industry enclosure costs.

  Both the average enclosure cost per machine ($3,437) and the average enclosure cost per machine operator ($63,364) are well above the respective averages for the industry.

- Cleaning and finishing equipment enclosures:

  Represent eight percent of the industry enclosure costs.

  The average cost/effectiveness ratio is $450/dBA. This value is the highest (lowest efficiency) for the industry.

Both the average enclosure costs per machine ($7,203) and the average enclosure costs per machine operator ($30,194) are higher than the respective averages for the industry.

SECTION V

PRODUCTIVITY LOSS BY ENCLOSURES

A review of 151 data sheets on noise reduction articles, abstracts and OSHA file cards (Reference 10) and the associated literature provides some conflicting information on productivity loss (or gain) associated with the use of enclosures. Three articles and two OSHA file cards provided information on enclosure/productivity relations (References 7 and 11 through 14). Allen and Ison (Reference 11), Bourne (Reference 14) and an OSHA file card on an enclosure for a bodymaker (Reference 12) indicated that there was no deleterious effect on production. Information on an enclosure for a cutoff saw (Reference 13) indicated a 15 percent loss in production associated with the enclosure. Verges (Reference 7) indicated mixed results in that, "experience shows that enclosures usually result in a production penalty - usually as much as 30 percent. In some cases, production returns to normal in about two weeks; and in one instance it eventually rose by 11 percent ...". The increase in productivity is probably the result of streamlining the manufacturing process to accomodate the enclosure.

SECTION VI

COSTS OF QUIET MACHINES

OVERVIEW

In assessing the costs of quiet machines the primary interest is the capital investment cost of machinery due to implementing noise reduction technology. The R&D costs, tooling costs, etc., associated with developing and manufacturing quiet machines are borne by other industries (e.g. machinery except electrical, SIC 35), and are either absorbed by those industries or passed on in terms of increased prices of the machines. The costs of quiet machines which directly impact the fabricated metal products industry, then, are the incremental prices of machines after noise reduction measures have been implemented. This measure offers a basis for direct comparison between the noise reduction alternatives of enclosing machines or buying quiet machines. (For the purpose of this report the life cycle status of the machines, the alternative or substituting processes, and the time associated with the development of quiet machines will not be treated.)

Several alternatives of estimating the costs of quiet machines were considered. These included estimating costs on the basis of: the data gathered for the technology assessment (Reference 10); IITRI's estimate; or a consultant's estimate. The data gathered for the technology assessment was insufficient to allow a meaningful cost estimate. IITRI's estimate would have required the gathering of additional data from industrial firms with machinery noise reduction experience. This was a possible alternative. The best alternative was to engage a consultant with expertise in the field.

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A review and evaluation of expert consultants indicated that Lyle F. Yerges had the desired background, data and willingness to generate the estimate. The A machine price data as well as the productivity loss estimates are based on Mr. Yerge's report (Reference 15).

INCREMENTAL QUIET MACHINERY COSTS

Average A machine cost, mean machine noise level, and number of machines, as compiled for each machine type (e.g. bench lathes) and for each machine class (e.g. turning machines), are given in Table B-1 of Appendix B.

The average A machine cost for the machine class is calculated as a weighted average of the A machine costs of the machine types.

SUMMARY OF A MACHINE COSTS, NOISE LEVELS, NUMBERS OF MACHINES AND OPERATORS

Table 3 is a summary compilation of Table B-1 of Appendix B. The column listing the number of machine operators for each machine class (Reference 9) is added for completeness. An inspection of this table indicates:

- Somewhat over 7 billion dollars would need to be spent by the industry as a noise related incremental machine cost.
- Average A machine costs vary from a low of $0 for die casting machines to a high of $10,000 for special way and transfer machines.
- The average A machine cost for the industry ($7.1 billion divided by 3.7 million machines) is about $1,900.
- 53 percent of the A machine costs are distributed over five machine classes; turning machines; mechanical presses-power, grinding machines, milling machines and drilling machines.
- 73 percent of the A machine costs are distributed over 10 machine classes; and
- The remaining 27 percent of the A machine costs are distributed over 21 machine classes.

Table 3. $ MACHINE COSTS, NOISE LEVELS, NUMBERS OF MACHINE AND OPERATORS

Machine Class	Average $ Machine Cost ($)	Total $ Machine Cost for Machine Class (Millions of Dollars)	Number of Machines in Class	Mean Machine Noise Level (dBA)	Number of Machine Operators (1973)
Turning Machines	2,000	970	493,477	91	91,370
Boring Machines	4,300	235	54,186	94	1,938
Drilling Machines	1,000	543	435,715	998	41,394
Milling Machines	2,200	634	288,139	966	15,997
Multifunction Machines	4,300	66	14,758	948*	1,309
Special Way and Transfer Machines	10,000	149	14,894	948	948
Automatic Assembly, Tapping and Threading Machines	4,000	377	89,375	93	8,813
Broaching Machines	3,500	51	14,630	918	748
Planning Machines	5,000	38	7,613	110	573
Shaping Machines	3,500	71	20,545	972	3,041
Cutoff, Sawing and Filing Machines	1,600	367	218,901	104	17,460
Grinding Machines	1,600	780	489,600	99	42,283
Honing Machines	4,500	91	20,733	998	998
Lapping Machines	1,500	30	19,320	998	456
Polishing and Buffing Machines	1,100	103	110,216	99	9,313
Gear Cutting & Finishing Machines	3,000	93	61,387	94	348
Electrical Machining Units	7,000	23	11,178	898	991
Other Metal Cutting Machines	1,500	23	15,829	998	993
Bending and Forming Machines - Power	1,500	150	98,311	103	29,793
Hydraulic and Pneumatic Presses	2,600	183	76,799	1018	9,994
Mechanical Presses - Power	2,800	809	290,979	998	100,811
Punching and Shearing Machines - Power	1,700	341	89,038	103	33,557
Forging Machines	8,600	335	37,767	108	9,931
Wire and Metal Ribbon Formers	3,000	138	36,915	98	3,554
Riveting Machines	3,000	111	33,351	118	9,101
Other Metal Forming Machines	3,000	78	18,767	88	6,691
Electric Arcwelding Equipment	400	143	383,000	97	71,901
Electric Resistance Welding Equipment	1,100	156	103,992	948	23,631
Other Joining Equipment	1,000	31	31,030	97	3,071
Bluecasting Machines	0	0	11,819	80	971
Cleaning and Finishing Equipment	2,500	383	148,011	101	34,841
TOTALS		7,099	3,730,764	--	511,95[illegible]

* 8 = estimated Machine Class Mean Noise Level.

SECTION VII

COST/EFFECTIVENESS OF QUIET MACHINES

A MACHINE EXPENDITURE VS. MAXIMUM TYPICAL NOISE LEVEL FOR INDUSTRY

A machine cost data for a machine class (column 3 of Table 3) can be combined with the mean machine noise level (column 5) to illustrate the incremental expenditure on quiet machines as a function of the noise reduction. If the noisiest machine class is treated first and then each subsequent noisiest machine class is treated the cost of quiet machines as a function of the maximum typical noise level for the industry is determined. This relationship is shown in Figure 3.

This figure illustrates the following:

- The cost-noise level relationship is an "S"-shaped curve whereby the most cost/effective zones are at the low and high ends of the curve. The curve shape is driven by 78 percent of the machines having noise levels between 90 and 100 dBA.
- Δcost/ΔdBA = $0.1 billion/dBA from 110 to 100 dBA.
- Δcost/ΔdBA = $0.5 billion/dBA from 100 to 90 dBA.
- Δcost/ΔdBA = $0.1 billion/dBA from 90 to 80 dBA.
- Reducing the maximum noise level of the industry to 100 dBA requires an incremental expenditure of 1.5 billion dollars.
- Reducing the maximum noise level of the industry to 95 dBA requires an expenditure of 3.5 billion dollars.
- Reducing the maximum noise level to 90 dBA requires 6.2 billion dollars.

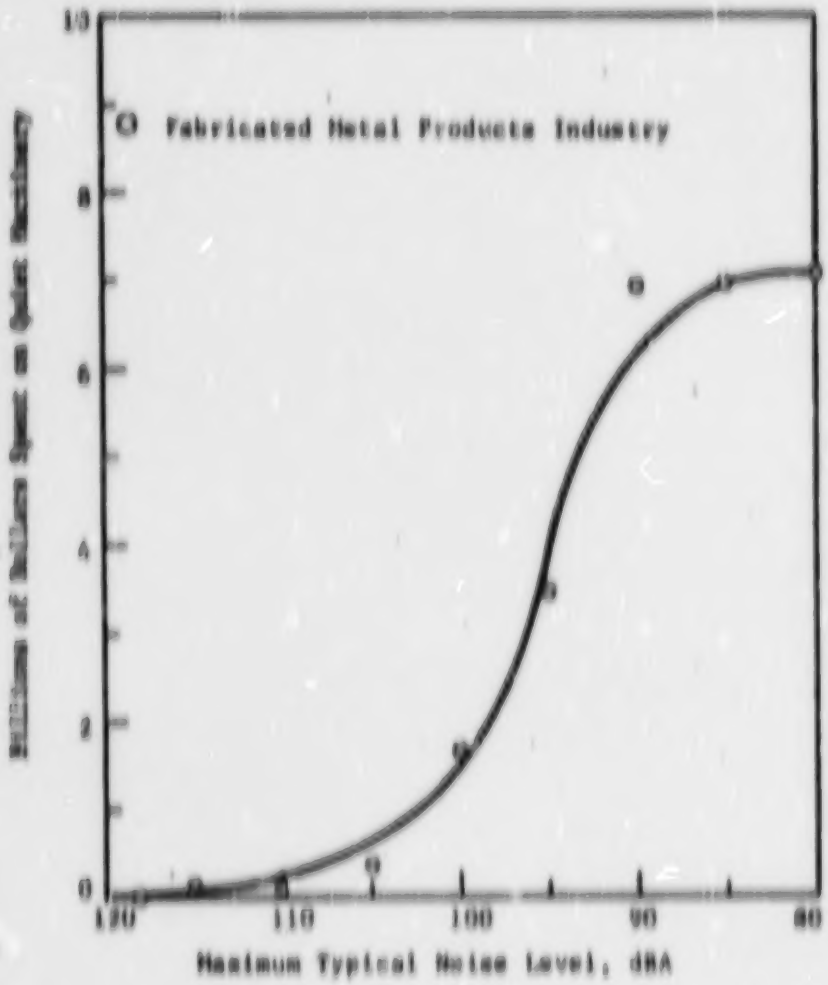

Figure 3. Quiet Machinery Expenditure Vs. Maximum Typical Noise Level for Industry.

- Reducing the maximum noise level to 85 dBA requires 7.0 billion dollars.

- Reducing the maximum noise level to 80 dBA requires 7.1 billion dollars.

INCREMENTAL EXPENDITURE ON QUIET MACHINES VS. REDUCTION IN THE NUMBER OF OPERATORS EXPOSED

Data from columns 3, 5 and 6 of Table 5 can be combined to develop the relationship between the incremental cost of quiet machines and the reduction in the number of machine operators exposed. This relationship is shown in Figure 4. The calculated data points, as derived from the table, are shown as the maximum typical noise level for the industry resulting from the expenditure. The machine classes were assumed to be treated according to their noise level rank - the loudest first, etc. A review of the figure indicates:

- The expenditure - exposure relationship is approximately linear up to a reduction of about 400,000 workers exposed. The relationship becomes slightly non-linear for the last 100,000 operators. The cost/effectiveness of quiet machine expenditure - on a number of operators exposed basis - is approximately constant.

- The average cost of protecting each machine operator to a level of 85 dBA is approximately $13,900 for industry wide protection.

- The average cost per operator is approximately $13,700 for industry wide protection to 90 dBA.

- The average cost per operator is approximately $11,400 for protection to 95 dBA.

- The average cost per operator is approximately $10,400 for protection to 100 dBA.

- The average cost per operator is approximately $10,000 for protection to 105 dBA.

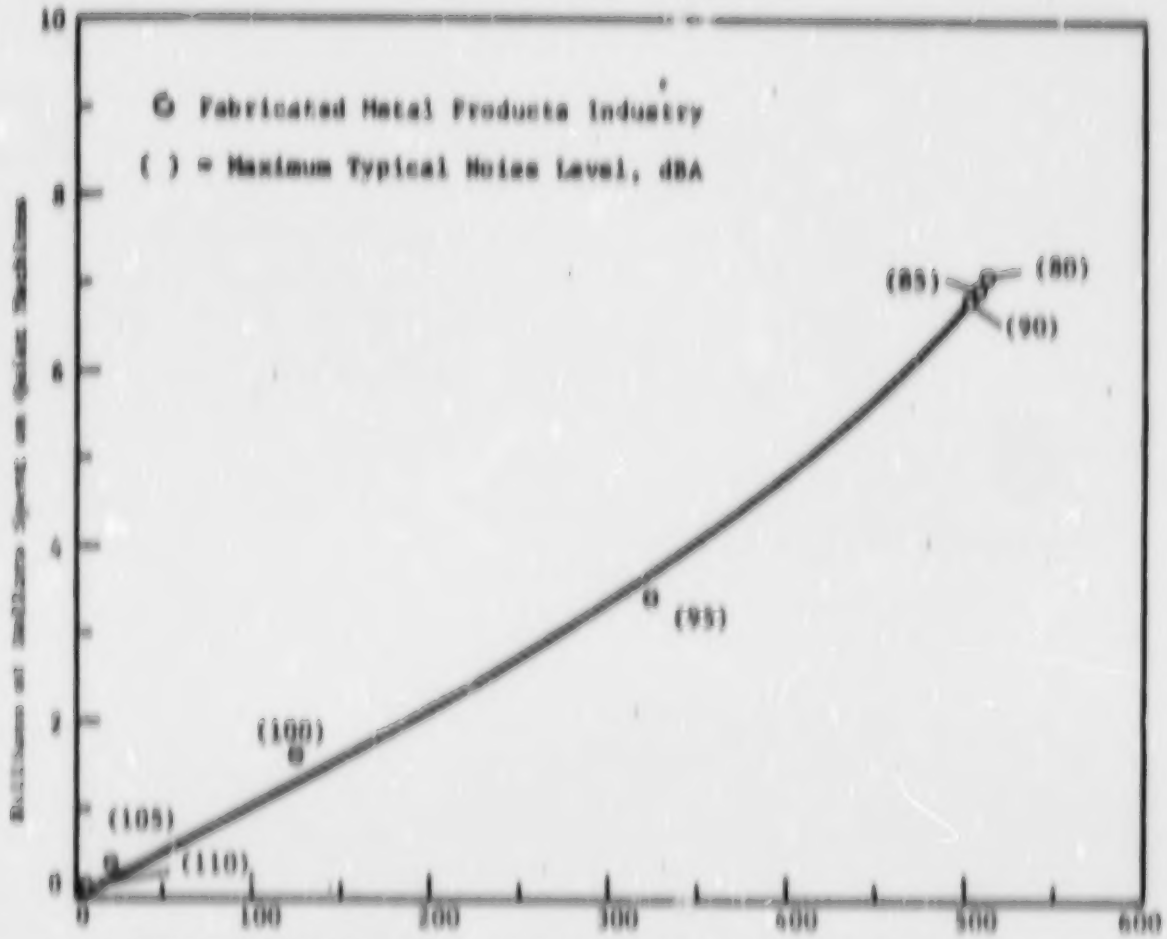

Figure 4. Quiet Machinery Expenditure Vs. Reduction in the Number of Machine Operators Exposed.

INCREMENTAL QUIET MACHINE COST SUMMARY

Table 4 is a summary compilation of incremental costs for quiet machines for the industry. The costs are distributed over the machine groups (e.g. metal cutting machines, metal forming machines, etc.) All "average" values presented in the table represent weighted averages which were derived from the data in Table 3.

Based on Table 4 the following are noted:

- For the industry:

  The average quiet machine cost/effectiveness ratio, which is a measure of how efficiently the machines are quieted, is $183/dBA.

  The average quiet machine cost per operator is approximately seven times the average quiet machine cost per machine. This reflects the "surplus" of machines over machine operators.

  If only those machines to which operators are assigned could be purchased as quiet machines the total incremental cost of the industry would drop from 7.1 billion dollars to a value closer to 1.0 billion dollars (average quiet machine cost per machine x number of machine operators).

- Quiet metal cutting machines:

  Represent 63 percent of the incremental quiet machine costs for the industry.

  The average cost/effectiveness ratio is $209/dBA.

  The average quiet machine cost per machine ($1,891) is near the average cost for the industry ($1,908). The average cost per machine operator ($23,003) is significantly above the industry average ($13,877).

- Metal forming machines:

  Represent 37 percent of the incremental quiet machine costs for the industry.

  The average cost/effectiveness ratio is $107/dBA.

Table 4. [illegible]

Machine Group	Total Quiet Machinery Cost for Group (Millions of Dollars)	Number of Machines in Group	Mean Group Noise Level (dBA)	Number of Machine Operators (1977)	Average Quiet Machine Cost per Operator ($)	Average Quiet Machine Cost per Machine ($)	Average Quiet Machine Cost/ Effectiveness Ratio ($/dBA) for 85 dBA
Wood Cutting Machines	4,467	2,382,335	95	194,195	23,003	1,891	259
Wood Forming Machines	1,934	703,297	102	181,807	10,638	2,750	197
Joining Equipment	332	498,802	96	99,699	3,330	667	64
Sharpening Machines	0	11,339	80	975	0	0	0
Covering and Finishing Equipment	365	144,813	101	34,841	10,460	2,508	156
TOTAL	7,098	3,738,354	97 (Average)	511,587	13,877 (Average)	1,908 (Average)	183 (Average)

The average incremental quiet machine cost per machine ($2,750) is above the average for the industry ($1,908). The average cost per machine operator ($10,638) is slightly below the industry average ($13,877).

- Joining equipment machines:

  Represent five percent of the incremental quiet machine costs for the industry.

  The average cost/effectiveness ratio is $64/dBA. This represents a relatively high levels of noise reduction efficiency.

  Both the average cost per machine ($667) and the average cost per machine operator ($3,330) are significantly below the respective averages for the industry.

- Die casting machines represent no noise reduction penalty to the industry. This relationship is driven primarily by the low mean group noise level (80 dBA).

- Cleaning and Finishing Equipment:

  Represent five percent of the incremental quiet machine costs for the industry.

  The average cost/effectiveness ratio is $156/dBA.

  The average costs per machine ($2,500) is significantly above the average for the industry ($1,908). The average costs per machine operator ($10,460) is slightly below the average for the industry ($13,877).

SECTION VIII

PRODUCTIVITY LOSS BY QUIET MACHINES

A productivity loss for each machine type was estimated by Vergas (Reference 15) based on data from his projects. These data represent productivity losses shortly after the machines were modified. During this period the manufacturing process which was used prior to the modification was either not modified or modified only slightly to accommodate the machinery or equipment change. It appears reasonable to expect that many of the productivity losses cited can be negated by process optimization. However, it is also reasonable to expect that in the instances in which the process has been optimized prior to effecting a change to a machine a productivity loss can be expected.

The productivity loss for each machine type was aggregated, on a weighting basis, and compiled by machine class. This compilation is presented as Table 5. An inspection of the table indicates:

- The average (weighted) productivity loss for the industry is in the order of nine percent.
- The average productivity loss ranges from a low of zero percent for electric arcwelding equipment, to a high of 15 percent for "other metalworking machines," riveting machines, and "other joining equipment."
- 10 of the 31 machine classes have an average productivity loss of ten percent or greater.
- Ten of the 31 machine classes have an average productivity loss of five percent or less.

Table 9. AVERAGE PRODUCTIVITY LOSS FOR MACHINE CLASS

Machine Class	Average Productivity Loss for Machine Class (%)	Number of Machines in Class
Turning Machines	<4	493,477
Boring Machines	<3	54,166
Drilling Machines	<14	435,713
Milling Machines	<5	388,139
Multifunction Machines	<5	14,738
Special Way and Transfer Machines	<3	14,854
Auto. Assy., Tapping and Threading Machines	<10	69,375
Broaching Machine	<5	14,620
Planning Machines	<10	7,613
Shaping Machines	<5	38,545
Cutoff, Saws and Filing Machines	<13	318,901
Grinding Machines	<12	489,600
Honing Machines	<10	20,723
Lapping Machines	<10	13,320
Polishing and Buffing Machines	<13	110,216
Gear Cutting and Finishing Machines	<5	1,387
Electrical Machining Unit	<10	11,176
Other Metalcutting Machines	<13	15,659
Bending and Forming Machines - Power	<10	98,311
Hydraulic and Pneumatic Presses	<10	76,709
Mechanical Presses - Power	<13	290,979
Punching and Shearing Machines - Power	<11	69,026
Forging Machines	<13	37,747
Wire and Metal Ribbon Formers	<10	26,315
Riveting Machines	<13	55,351
Other Metal Forming Machines	<7	38,767
Electric Arcwelding Equipment	0	363,020
Electric Resistance Welding Equipment	<14	103,952
Other Joining Equipment	<15	31,030
Diecasting Machines	<10	11,219
Cleaning and Finishing Equipment	<5	148,013
TOTALS	9 (Average)	3,720,784

The productivity loss for each machine class was then aggregated, on a weighted basis, and compiled by machine group. Table 6 illustrates this compilation. An inspection of this table indicates:

- Metal cutting, metal forming and die casting machinery represent the major productivity loss groups with productivity losses between nine and 13 percent. They also represent 83 percent of the machines. If the die casting machines group is not included, by virtue of the low noise level, the two remaining groups still represent 83 percent of the machines in the industry.

- Joining equipment and cleaning and finishing equipment groups have average productivity loss penalties of less than five percent.

Table 6. AVERAGE PRODUCTIVITY LOSS BY MACHINE GROUP

Machine Group	Average Productivity Loss for Machine Group (%)	Number of Machines in Group
Metal Cutting Machines	<9	1,362,433
Metal Forming Machines	<12	703,397
Joining Equipment	<4	498,002
Diecasting Machines	<10	11,219
Cleaning and Finishing Equipment	<5	146,013
TOTAL	<9 (Average)	3,720,764

SECTION IX

COMPARISON OF ENCLOSURE AND INCREMENTAL MACHINERY COST EXPENDITURES

BY MACHINE CLASS

Table 7 is a compilation of average costs and total cost for each machine class. Incremental machine costs and enclosure costs are compiled in adjacent columns. A comparison of the average costs indicates:

- Average incremental machinery costs are consistently below average enclosure costs. The only inverse of this position is for the riveting machines - in this instance the costs of each option are approximately equal.
- The relative high cost - low cost trend is reasonably consistent. A machine class in which the enclosure cost is below the average for the industry generally has a Δ machine cost below the industry average. The exceptions are in the classes of planing machines, bending and forming machines, and cleaning and finishing equipment. In these classes the Δ machine costs are significantly below the enclosure costs.

An inspection of the total cost indicates:

- The average cost trends discussed above also apply to the total costs for the machine classes.
- The total cost for the industry is significantly less ($3.9 billion dollars) if the quiet machinery option is selected.

Table 7. MACHINE AND ENCLOSURE COST COMPARISON FOR THE MACHINE CLASS

Machine Class	Average A Machine Cost ($)	Average Enclosure Cost ($)	Total A Machine Cost for Machine Class (Millions of Dollars)	Total Enclosure Cost for Machine Class (Millions of Dollars)
Forging Machines	1,900	3,000	973	1,477
Boring Machines	4,300	4,700	330	387
Drilling Machines	1,300	2,300	343	1,001
Milling Machines	3,300	5,900	634	1,133
Multifunction Machines	4,300	9,000	66	94
Special Way and Transfer Machines	10,000	13,300	149	198
Automatic Assembly, Tapping and Threading Machines	4,900	4,300	277	291
Broaching Machines	3,500	6,600	51	96
Planing Machines	5,000	33,900	38	258
Shaping Machines	3,500	3,500	71	71
Cutoff, Sawing and Filing Machines	1,600	3,000	367	661
Grinding Machines	1,600	2,600	780	1,269
Honing Machines	1,500	2,100	31	43
Lapping Machines	1,500	2,300	30	39
Polishing and Buffing Machines	1,100	1,100	133	133
Laser Cutting & Finishing Machines	2,000	3,100	83	129
Electrical Machining Units	2,000	2,100	33	34
Other Metal Cutting Machines	1,900	3,000	33	47
Bending and Forming Machines - Power	1,500	6,000	133	793
Hydraulic and Pneumatic Presses	2,400	3,900	183	301
Mechanical Presses - Power	3,800	4,600	803	1,339
Punching and Shearing Machines - Power	3,700	3,700	241	337
Forging Machines	8,600	9,300	331	398
Wire and Metal Ribbon Formers	3,000	3,800	138	133
Riveting Machines	2,600	1,900	111	108
Other Metal Forming Machines	2,000	2,900	78	113
Electric Arcwelding Equipment	400	1,600	163	590
Electric Resistance Welding Equipment	1,300	2,700	156	378
Other Joining Equipment	1,800	3,600	31	111
Electrostatic Machines	0	3,500	0	61
Cleaning and Finishing Equipment	3,300	7,500	365	1,033
	TOTALS		7,000	12,000

BY MACHINE GROUP

Table 8 is a comparison compilation of costs and cost/effectiveness of quiet machinery vs. enclosures for the five machinery groups. The following are noted:

- The total quiet machinery costs is significantly below that of enclosures.
- Similarly, the average incremental cost per quiet machine is almost half the cost of the average enclosure.
- The incremental cost of quiet machines is uniformly below the enclosure costs.
- On a cost/effectiveness basis the quiet machine is a better choice.

Table 8. [illegible]

Machine Group	Total Gulet Machinery Cost for Group (Billions of Dollars)	Total Enclosure Cost for Machine Group (Billions of Dollars)	Average Gulet Machine Cost per Operator ($)	Average Enclosure Cost per Machine ($)	Average Gulet Machine Cost/ Effectiveness Ratio ($/dBA) in 85 dBA	Average Enclosure Cost/ Effectiveness Ratio ($/dBA) in 85 dBA
Metal Cutting Machines	4,467	7,177	1,891	3,038	209	335
Metal Forming Machines	1,934	3,379	2,750	4,805	187	326
Joining Equipment	332	981	667	1,970	64	190
Dismantling Machines	0	61	0	5,437	0	0
Cleaning and Finishing Equipment	365	1,652	2,500	7,305	256	450
TOTAL	7,098	12,650	1,900 (Average)	3,400 (Average)	183 (Average)	308 (Average)

SECTION 8

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APPENDIX A

ENCLOSURE AND MACHINE SIZES AND ENCLOSURE COSTS

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

4 Turning Machines

Machine Type		Length (Ft)	Width (Ft)	Height (Ft)	Enclosure Surface Area (Ft^2)	Average Enclosure Surface Area (Ft^2)
Bench Lathe		3B	1B	1B	184	226
		4B	1B	1B	204	
		5B	2B	2B	248	
		6B	2B	2B	289	
Engine and Toolroom Lathe	< 9 inch swing	5B	3B	5B	272	294
		6B	3B	5B	294	
		7B	3B	5B	316	
	9-16 inch swing	7.5	3.3	5B	343	330
		6.8	3.5	5B	317	
	17-23 inch swing	9.3	4.3	5B	401	401
	> 24 inch swing	13.7	4.3	6B	554	687
		11.9	4.9	6B	528	
		14.5	7.3	6B	673	
		17.0	9.0	6B	816	
		15.4	6.6	6B	681	
		17.5	8.8	6B	834	
		16.7	7.1	6B	735	
Tracer Lathe		10.3	5.6	9B	640	799
		11.2	5.6	9B	668	
		11.1	5.8	9B	674	
		13.3	5.8	9B	747	
		16.6	5.8	9B	854	
		13.3	6.0	9B	755	
		16.6	6.0	9B	862	
		32B	3B	9B	1312	
		11.1	6.0	9B	681	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

g Turning Machines (Contd)

Machine Type	Length (Ft)	Width (Ft)	Height (Ft)	Enclosure Surface Area (Ft^2)	Average Enclosure Surface Area (Ft^2)
Turret Lathe(Ram Type)	8E	3E	5E	330	327
	7E	3E	5E	316	
Turret Lathe(Saddle Type)	12E	7E	6E	500	374
	5E	3E	5E	248	
Automatic Chucking Single Spindle	9.7	13.3	10.9	1015	705
	7.3	10.1	9.4	715	
	5.0	7.2	8.3	492	
	6.2	8.3	9.0	596	
Automatic Chucking Multispindle	7.5	7.5	14E	836	687
	8.3	8.3	14E	896	
	5.0	7.2	8.5	500	
	6.2	8.3	9.0	596	
	13.8	6.7	8E	747	
	13.0	5.5	8E	676	
	13.8	5.8	8E	712	
	13.0	4.9	10E	748	
	9.2	4.3	7E	479	
Automatic Between Centers Chucking	12E	4E	6E	501	490
	9.2	4.3	7E	479	
Automatic Bar Machines Single Spindle	10E	4E	5E	411	431
	5E	3E	5E	273	
	11.8	5.7	9E	693	
	23.9	5.7	10E	1339	
Automatic Bar Machines Multispindle	16.3	3.3	10E	853	941
	18.6	3.9	10E	891	
	19.8	4.5	12E	1081	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Turning Machines (Cont'd)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Vertical Turning and Boring Mills	38	38	38	328	1469
	48	38	88	386	
	38	68	108	514	
	78	88	148	824	
	88	108	168	1088	
	98	118	188	1268	
	368	258	488	7928	
	68	38	88	448	
	78	68	108	784	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Boring Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Horizontal Bore, Floor and Table Type	38	38	38	330	478
	48	38	48	396	
	58	68	48	344	
	188	48	138	1043	
Horizontal Bore, Floor Type	58	58	58	320	607
	58	68	58	336	
	158	108	128	1164	
Precision, Horizontal and Vertical	108	148	128	1121	1121
Jig Borers, Horizontal and Vertical	5.7	4.8	13.0	564	846
	138	58	108	750	
	128	128	128	1125	
	11.1	8.9	108	844	
	15.8	10.2	138	1146	
	13.5	11.1	148	1275	
	13.7	11.4	148	1298	
	5.3	7.8	78	472	
	3.3	5.6	78	353	
	15.1	10.3	98	1160	
	4.3	3.5	78	323	

Table A.1

ENCLOSURE/MACHINE DIMENSIONS SUMMARY

1. Drilling Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Sensitive, Bench	3E	2E	3E	185	185
Sensitive, Floor and Pedestal	3E	2E	7E	335	379
	3.4	3.0	7.5	325	
Upright, Single Spindle	3E	3E	7E	350	487
	3E	3E	8E	390	
	9.0	9.3	13E	910	
Upright, Gang	4E	3E	8E	338	338
Upright, Turret	4E	4E	10E	413	413
Radial	3E	5E	8E	356	494
	5E	4E	7.9	382	
	6E	4E	7.9	411	
	5E	4E	8.8	410	
	6E	4E	8.8	441	
	7E	4E	8.8	472	
Multispindle Cluster	5E	3E	7E	320	486
	5E	7E	11E	564	
Deep Hole	16E	4E	6E	601	601

Table A.1

ENCLOSURE/MACHINE DIMENSIONS SUMMARY

a. Milling Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Bench Type	3E	3E	4E	32E	32E
Bed	6E	6E	7E	49E	49E
Vertical, Ram Type	7E	6E	7E	47E	51E
	6E	7E	7E	55E	
General Purpose, Horizontal Knee or Bed	6E	3E	6E	31E	51E
	7E	3E	7E	38E	
	9E	3E	9E	50E	
	12E	4E	10E	67E	
	15E	5E	10E	83E	
General Purpose, Vertical Knee or Bed	17E	6E	10E	103E	103E
Manufacturing, Knee or Bed	11E	6E	8E	63E	63E
Planer Type	12E	7E	8E	70E	191E
	30E	16E	16E	260E	
	20E	9E	13E	139E	
	24E	12E	10E	149E	
	30E	7E	9E	136E	
Profiling and Duplicating	9E	3E	6E	30E	62E
	10E	4E	7E	49E	
	20E	6E	8E	91E	
	3E	6E	6E	32E	
	6E	7E	6E	43E	
	4E	6E	6E	35E	
	6E	6E	6E	45E	
	6E	6E	7E	49E	
	9E	8E	8E	63E	
	12E	12E	10E	100E	
	15E	8E	18E	141E	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Multifunction Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Drill-Mill-Bore, Manual Toolchange	12ft	4ft	9ft	633	609
	6ft	7ft	10ft	584	
Drill-Mill-Bore, Automatic Toolchange, Vertical	8ft	5ft	12ft	658	1139
	13ft	5ft	12ft	848	
	17ft	5ft	12ft	1008	
	21ft	9ft	13ft	1152	
	39ft	10ft	15ft	2036	
Drill-Mill-Bore, Automatic Toolchange, Horizontal	13ft	13ft	15ft	1408	1357
	12ft	12ft	15ft	1305	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

a Special Way-Type and Transfer Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Single Station	15ft	6ft	8ft	990	685
	7ft	3ft	7ft	380	
Multistation, Rotary Transfer	15ft	6ft	10ft	864	864
Multistation, In-Line Transfer	60ft	40ft	10ft	5465	3119
	30ft	10ft	6ft	1091	
	90ft	15ft	10ft	2800	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Broaching and Planning Machines

Machine Type	Length (Ft)	Width (Ft)	Height (Ft)	Enclosure Surface Area (Ft^2)	Average Enclosure Surface Area (Ft^2)
Broaching Machine, Internal	14E	4E	14E	935	1079
	18E	4E	8E	763	
	16E	4E	16E	1121	
	19E	5E	19E	1496	
Broaching Machine, Surface	14E	4E	14E	935	1130
	16E	4E	5E	549	
	14E	16E	19E	1907	
Planning Machines, Double Column	34E	17E	13E	2044	2334
	37E	8E	10E	1322	
	40E	15E	16E	3336	
Planning Machines, Openside	150E	50E	35E	19,648	10,803
	30E	14E	13E	1961	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

4. Shaping Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Shaper, Horizontal	4X	9X	5X	366	416
	4X	8X	6X	401	
	4X	7X	6X	376	
	3X	8X	5X	330	
	4X	9X	6X	456	
	5X	10X	8X	566	
Shaper, Vertical	4X	6X	8X	415	415

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

a Cutoff, Sawing and Filing Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Contour Saws	38	68	78	354	399
	48	78	88	444	
Hacksaw	17.7	7.3	4.9	703	305
	8.8	3.8	9.1	449	
	10.2	6.7	13.6	754	
	5.1	2.3	4.3	257	
	5.6	2.3	4.3	288	
	3.9	4.0	78	326	
	6.0	2.0	78	325	
	4.2	1.8	78	275	
	3.9	1.6	78	262	
	3.2	1.4	78	239	
	14.9	8.4	11.8	1072	
	16.3	8.4	11.8	1130	
Circular Saw	38	68	88	384	385
	28	38	48	185	
Abrasive Wheel	168	48	98	757	757
Bandsaw, Vertical	6.6	6.4	6.6	434	484
	6.6	7.1	7.8	523	
	7.3	6.4	7.3	517	
	4.2	7.3	7.3	442	
Bandsaw, Horizontal	15.8	7.6	7.8	1015	547
	5.3	5.0	68	393	
	6.0	4.0	68	397	
	8.8	6.1	68	483	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

a. Grinding Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
External, Plain Center	5.4	5.4	6ft	375	375
External, Universal Center	8.6	7.5	7ft	570	881
	17.0	10.0	8ft	986	
	14.3	12.0	10ft	1087	
External, Centerless	6ft	3ft	5ft	369	393
	7ft	3ft	5ft	316	
External, Chucking	5ft	4ft	5ft	296	296
Internal	5ft	3ft	5ft	248	248
Surface, Rotary Table	6ft	3ft	7ft	325	325
Surface, Reciprocating	3ft	2ft	5ft	206	241
	4ft	3ft	6ft	276	
Disc	5.5	8.0	7ft	484	660
	7.0	13.0	8ft	700	
	10.0	14.0	8ft	881	
	7.0	13.0	7ft	650	
	8.0	11.0	10ft	693	
	6.0	8.0	10ft	549	
Abrasive Belt	15ft	4ft	7ft	896	1119
	20ft	10ft	7ft	1019	
	30ft	10ft	5ft	1441	
Contour	5.0	3.7	6.0	318	357
	5.0	4.9	6ft	369	
	7ft	5ft	6ft	404	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

e Grinding Machines (Cont'd)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Thread	6.0	5.0	7ft	435	516
	5ft	4ft	5ft	296	
	6ft	5ft	5ft	344	
	5ft	5ft	5ft	348	
	10ft	4ft	7ft	707	
	25ft	6ft	6ft	1066	
Tool and Cutter	3ft	2ft	5ft	206	206
Bench, Floor and Snag	3ft	4ft	6ft	176	176
Jig	11.1	8.9	9ft	793	910
	11.8	8.9	9ft	817	
	12.8	10.4	9ft	913	
	13.5	11.1	10ft	1036	
	13.7	11.4	10ft	1049	
Ultrasonic	1.4	1.0	2.4	152	189
	3.5	3.1	6.0	366	
	1.2	1.0	1.6	148	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Honing Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Internal	5.8	5.5	5.5	265	353
	2.9	2.9	7.5	370	
	6.5	5.5	6.5	384	
	4.5	6.5	10.5	479	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

1. Lapping Machines and Polishing Stands

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Flat Surface	6ft	3ft	5ft	269	393
	3ft	3ft	6ft	252	
	8ft	6ft	8ft	539	
Cylindrical	9ft	4ft	7ft	464	464
Polishing Stands	2ft	3ft	4ft	185	185

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Gear Cutting and Finishing Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Hobbers	38	38	58	330	539
	38	38	68	353	
	911	38	78	432	
	68	38	88	384	
	98	48	78	484	
	108	48	98	571	
	98	48	98	540	
	208	68	158	1359	
Shapers	3.7	3.5	68	233	497
	5.7	4.7	68	311	
	5.9	3.4	58	284	
	6.5	5.0	78	420	
	4.7	6.8	78	423	
	5.3	4.0	68	334	
	6.9	4.7	68	393	
	17.2	12.1	158	1979	
Face-Milling Type	68	38	68	341	474
	98	38	98	504	
	128	48	108	677	
Bevel-Gear Cutter	128	78	78	650	650

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Gear Cutting and Finishing Machines (Group)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Finishers	15.0	10.0	7.0	654	487
	8.0	6.0	8.0	603	
	8.0	8.0	10.0	693	
	9.0	4.0	7.0	484	
	3.0	3.0	7.1	375	
	3.0	3.0	7.4	391	
	3.0	3.0	7.9	400	
	13.7	9.9	6.1	723	
	14.3	9.9	6.5	797	
	8.1	6.9	6.0	488	
	8.1	7.5	6.0	505	
	4.7	4.3	4.7	296	
	1.7	1.0	50	175	
	3.0	3.5	5.3	365	
	2.9	2.9	7.5	378	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Electrical Milling Units

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
	48	28	78	875	
	68	48	88	415	
	58	38	78	328	
BBH	8.1	3.8	9.8	331	329
	9.3	3.8	9.9	333	
	5.1	3.9	7.3	365	
	6.6	4.8	7.9	434	
	128	78	98	790	
BDM	88	138	138	945	857
	48	58	58	876	
BLO or BDC	68	48	78	383	383

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Bending and Forming Machines-Power

Machine Type	Length (Ft)	Width (Ft)	Height (Ft)	Enclosure Surface Area (Ft^2)	Average Enclosure Surface Area (Ft^2)
Bending Rolls, Sheet and Plate	5B	2B	7B	300	500
	6B	3B	8B	353	
	5B	2B	7.1	303	
	6B	3B	7.4	366	
	6B	3B	7.9	381	
	6B	3B	9.6	432	
	7B	4B	11.3	556	
	7B	4B	13.0	652	
	8B	3B	16.1	614	
	8B	3B	16.3	618	
Bending Rolls, Bar	4B	3B	7B	302	461
	7B	7B	10B	620	
Press Brakes, Mechanical	20B	10B	17B	1739	1739
Press Brakes, Hydraulic and Pneumatic	30B	15B	15B	2430	2430

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Hydraulic and Pneumatic Presses (Except Forging)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
	3.5	3.0	6.5	335	
	3.9	3.0	6.5	349	
	4.6	4.6	10.5	466	
	5.0	5.3	10.4	503	
	5.1	5.7	11.1	565	
	5.8	5.8	13.5	658	
	6.4	5.8	15.8	694	
	7.7	6.6	15.8	866	
	7.8	7.2	16.1	912	
	9.4	8.2	16.3	1140	
	9.6	8.3	19.0	1194	
	9.8	8.5	19.5	1240	
	3.9	3.8	10.8	425	
Vertical, Single Action	4.2	4.5	10.8	460	629
	4.5	5.0	11.1	497	
	5.0	5.1	11.5	541	
	5.7	5.1	12.1	578	
	5.7	5.2	12.1	582	
	6.9	6.1	14.0	736	
	7.0	6.3	14.0	749	
	7.1	6.4	14.1	762	
	3E	4E	7.1	305	
	3E	4E	7.4	312	
	5E	5E	7.7	406	
	5E	5E	7.8	410	
	5E	5E	9.6	487	
	5E	6E	11.3	558	
	5E	6E	11.3	558	
	5E	6E	15.0	684	
	6E	7E	16.1	816	
	6E	7E	16.3	823	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

e Hydraulic and Pneumatic Presses (Except Forging) (Cont.)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Vertical, Double and Triple Action	68	128	188	1143	1143
Horizontal, Single Action	6.3	3.4	18	308	351
	7.1	3.6	38	334	
	7.3	4.8	48	385	
	7.9	5.3	48	403	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

Mechanical Presses-Power (Except Forging)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Gunable, Single Action	108	68	168	953	953
	3.9	4.0	8.0	314	
	3.0	4.0	8.5	341	
	3.0	5.0	9.0	384	
	3.3	6.0	11.0	485	
ge or C-Frame	3.3	6.5	11.5	518	516
	3.3	6.5	12.0	534	
	4.0	7.0	14.5	665	
	4.0	7.0	158	682	
	4.0	8.0	15.0	725	
	2.6	3.5	6.7	271	
	3.0	7.3	6.7	378	
	2.3	2.5	6.0	234	
	2.3	2.5	6.3	230	
	2.7	2.5	6.3	260	
	3.1	3.7	6.5	284	
traight-Side, ingle Action	3.1	3.7	6.7	289	369
	3.6	4.0	7.2	324	
	3.6	5.0	7.9	371	
	4.3	5.3	9.2	441	
	4.3	5.3	9.6	454	
	4.3	5.3	10.1	469	
	4.3	5.3	5.3	320	
	10.1	9.3	9.8	819	
traight-Side, ouble or Triple Action	68	128	188	1143	1143
nuckle-Joint (Embossing)	58	58	188	736	736

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

e Mechanical Presses-Power (Except Forging) (Cont.)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Adjustable, Bed and Herning	4E	4E	7E	329	329
Full-Down Punching and Stamping	5.0	5.0	9.6	494	732
	5.8	5.5	11.7	583	
	5.8	6.3	12.3	636	
	6.0	6.6	13.0	711	
	6.7	7.0	13.8	846	
	6.9	7.8	14.1	905	
	9.2	7.9	14.6	946	
Multiple-Transfer, Automatic	16E	8E	30E	1589	1589

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

e Punching and Shearing Machines-Power

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Punching, Fixed Position	7.3	3.7	7ft	406	442
	7.1	4.8	7ft	440	
	7.9	5.5	7ft	481	
Plate and Sheet Shears, Mechanical	10ft	6ft	6ft	513	703
	14ft	6ft	14ft	1037	
	10ft	6ft	7ft	557	
Plate and Sheet Shears, Hydraulic	10ft	6ft	6ft	513	703
	14ft	6ft	14ft	1037	
	10ft	6ft	7ft	557	

Table 4.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Forging Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Presses, Mechanical	30ft	30ft	30ft	3563	3563
Presses, Hydraulic	21ft	10ft	42ft	3642	7972
	30ft	30ft	36ft	6237	
	40ft	40ft	60ft	14,037	
Hammers, Single Action	16ft	6ft	24ft	1683	977
	4ft	7ft	10ft	518	
	6ft	6ft	22ft	1321	
	6ft	5ft	12ft	582	
	8ft	5ft	18ft	886	
Hammers, Double Action	7ft	5ft	16ft	764	764
Headers, Hot or Cold	12ft	6ft	7ft	615	615
Rolls and Bragers	4ft	6ft	9ft	447	493
	8ft	8ft	9ft	649	
	6ft	4ft	7ft	383	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Wire and Metal-Ribbon Formers

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Wire Former	208	68	78	964	964

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

* Riveting Machines (Not Portable)

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Squeeze Type	8.6	3.5	6.7	371	385
	3.0	7.3	6.7	378	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

9 Other Metal Forming Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Thread Rolling Machines	108	58	68	482	645
	128	128	68	768	
	108	108	78	689	
Cold Forming Machines	6.8	5.8	6.3	432	436
	7.0	6.6	5.8	441	
	9.0	6.6	5.8	485	
	11.3	7.8	6.2	597	
	3.0	2.5	4.9	196	
	5.9	5.9	5.2	396	
Spinning Machines	68	58	78	618	618

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

Electric Arcwelding Equipment

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Manual Welding Equipment, Generator Type	4B	6B	5B	319	319
Manual Welding Equipment, Transformer Type	9B	3B	5B	306	306
Manual Welding Equipment, Rectifier Type	3B	3B	4B	228	228
Semiautomatic Machines	4B	4B	5B	273	273
Automatic Machines	10B	8B	8B	671	645
	6B	6B	10B	619	

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Electric Resistance Welding Equipment

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Spot	4ft	4ft	6ft	304	464
	4ft	4ft	9ft	357	
	8ft	4ft	5ft	357	
	15ft	4ft	12ft	972	
Seam	3ft	10ft	8ft	496	536
	5ft	9ft	9ft	576	
Butt and Flash	3ft	3ft	3ft	306	306

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Plastics Molding and Diecasting Machines

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Plastics Injection Molding Machine	14B	4B	6B	55I	556
	6B	3B	9B	4I6	
	13B	6B	7B	703	
Plastics Compression Molding Machine	20B	15B	10B	1480	1787
	42B	10B	10B	2093	
Diecasting Machine	18B	6B	9B	909	909

Table A.1

ENCLOSURE/MACHINE/DIMENSIONS SUMMARY

• Cleaning and Finishing Equipment

Machine Type	Length (ft)	Width (ft)	Height (ft)	Enclosure Surface Area (ft^2)	Average Enclosure Surface Area (ft^2)
Barrel Finishing Machines	88	88	138	781	538
	68	38	58	294	
Vibratory Finishing Machines	88	88	68	917	917
Shot, Abrasive and Other Blast Units	78	78	158	830	830
Parts Washing Machine	108	68	28	489	489
Plating Machine	1208	158	188	8136	8136

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Turning Machines

Number of Machines in Class: 493,647

Average Enclosure Area, ft^2: 499

Average Enclosure Cost, $: 3,924

Mean Noise Level, dBA: 91

Total Enclosure Cost for Machine Class, $: 1,477,000,000

Machine Type		Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Bench Lathes		226	-	61,993	84,062,000
Engine and Toolroom	≤ 8 inch swing	294	89	31,209	55,046,000
	9-16 inch swing	330	89	99,226	196,467,000
	17-23 inch swing	401	89	41,773	100,506,000
	≥ 24 inch swing	587	89	19,090	78,689,000
Tracer Lathes		799	88	14,918	71,917,000
Turret Lathes, Ram Type		327	93	44,908	88,109,000
Turret Lathes, Saddle Type		375	93	28,229	63,919,000
Automatic Chucking, Single-Spindle		705	90	21,574	15,210,000
Automatic Chucking, Multispindle		687	90	10,588	43,644,000
Automatic Between Centers Chucking		490	90	6,189	18,196,000
Automatic Bar Machines, Single-Spindle		651	93	47,375	185,047,000

Table A.3

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Turning Machines (Concl)

Number of Machines in Class: 493,447

Average Enclosure Area, ft^2: 499

Average Enclosure Cost, $: 2,994

Mean Noise Level, dBA: 91

Total Enclosure Cost for Machine Class, $: 1,477,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Automatic Bar Machines, Multispindle	941	95	33,695	190,342,000
Vertical Turning and Boring Mills	1469	93	19,216	169,370,000
Other Lathes	499A	-	13,468	40,323,000

Table 4.3

ENCLOSURE/NO. 8 LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Boring Machines

Number of Machines in Class: 34,168

Average Enclosure Area, ft^2: 790

Average Enclosure Cost, $: 4,740

Mean Noise Level, dBA: 94

Total Enclosure Cost for Machine Class, $: 237,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Horizontal Bore, Drill, Mill, Table and Planer Type	478	-	11,234	39,319,000
Horizontal Bore, Drill, Mill, Floor Type	607	-	11,605	42,365,000
Precision	1121	-	14,493	97,493,000
Jig Borers	846	-	14,598	74,099,000
Other	790A	-	2,234	10,589,000

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Drilling Machines

Number of Machines in Class: 455,713

Average Enclosure Area, ft^2: 366

Average Enclosure Cost, $: 2,196

Mean Noise Level, dBA: 93

Total Enclosure Cost for Machine Class, $: 1,001,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Sensitive, Bench	185	=	98,253	109,061,000
Sensitive, Floor and Pedestal	279	=	85,347	140,823,000
Upright, Single-Spindle	487	=	139,487	407,581,000
Upright, Gang	328	=	40,977	80,643,000
Upright, Turret	413	=	9,781	34,240,000
Radial	494	=	44,633	133,349,000
Multispindle Cluster	486	=	23,068	67,266,000
Deep Hole	601	=	5,648	20,367,000
Other	366A	=	8,501	18,668,000

Table A.3

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Milling Machines

Number of Machines in Class: 288,139

Average Enclosure Area, ft^2: 651

Average Enclosure Cost, $: 3,906

Mean Noise Level, dBA: 96

Total Enclosure Cost for Machine Class, $: 1,125,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Bench Type	328	=	14,956	23,196,000
Hand	499	=	19,457	58,354,000
Vertical, Ram Type	510	=	57,456	175,815,000
General Purpose, Knee or Bed, Horizontal	514	=	70,810	218,178,000
General Purpose, Knee or Bed, Vertical	1026	=	66,360	409,743,000
Manufacturing, Knee or Bed	651	=	20,309	77,012,000
Planer Type	1513	=	4,592	41,659,000
Profiling and Duplicating	651	=	17,401	64,816,000
Thread Millers	651A	=	4,163	16,261,000
Other	651A	=	10,455	40,837,000

Table A.3

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Multifunction Machines

Number of Machines in Class: 14,738

Average Enclosure Area, ft^2: 841

Average Enclosure Cost, $: 5,046

Mean Noise Level, dBA: --

Total Enclosure Cost for Machine Class, $: 74,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Drill-Mill-Bore, Manual Toolchange	609	-	7,178	36,231,000
Drill-Mill-Bore, Indexing Turret	841A	-	3,546	17,893,000
Drill-Mill-Bore, Automatic Toolchange, Vertical	1139	-	1,855	12,677,000
Drill-Mill-Bore, Automatic Toolchange Horizontal	1357	-	2,191	17,913,000

Table A.8

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Special Way-Type and Transfer Machines

Number of Machines in Class: 14,854

Average Enclosure Area, ft^2: 2,222

Average Enclosure Cost, $: 13,337

Mean Noise Level, dBA: 94

Total Enclosure Cost for Machine Class, $: 198,700,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Single Station	685	-	3,923	16,134,000
Multistation, Rotary Transfer	864	-	5,846	30,306,000
Multistation, In-Line Transfer	3119	-	5,085	99,161,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Automatic Assembly, Tapping and Threading Machines

Number of Machines in Class: 69,375

Average Enclosure Area, ft^2: 699

Average Enclosure Cost, $: 4,194

Mean Noise Level, dBA: 92

Total Enclosure Cost for Machine Class, $: 291,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Automatic Assembly Machines	1920	-	17,290	199,181,000
Tapping Machines	267	94	36,340	58,217,000
Threading Machines	356	89	15,745	33,631,000

Table A.5

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Broaching Machines

Number of Machines in Class: 14,620

Average Enclosure Area, ft^2: 1,097

Average Enclosure Cost, $: $6,584

Mean Noise Level, dBA: n/a

Total Enclosure Cost for Machine Class, $: $96,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Internal	1079	-	9,499	61,497,000
Surface and Other	1130	-	5,121	34,720,000

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Planing Machines

Number of Machines in Class: 7,612

Average Enclosure Area, ft^2: 5,655

Average Enclosure Cost, $: 33,930

Mean Noise Level, dBA: 110

Total Enclosure Cost for Machine Class, $: 258,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Double Column	3834	-	4,573	61,396,000
Openside and Other	10,803	-	3,039	196,982,000

Table A.3

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Shaping Machines

Number of Machines in Class: 38,345

Average Enclosure Area, ft^2: 416

Average Enclosure Cost, $: 2,496

Mean Noise Level, dBA: 99

Total Enclosure Cost for Machine Class, $: 71,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Horizontal	416	-	22,139	55,309,000
Vertical	419	-	6,386	15,901,000

Table A.3

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Cutoff, Sawing and Filing Machines

Number of Machines in Class: 218,901

Average Enclosure Area, ft^2: 503

Average Enclosure Cost, $: 3,030

Mean Noise Level, dBA: 104

Total Enclosure Cost for Machine Class, $: $663,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Contour Saws	399	97	23,384	56,460,000
Hacksaw	909	107	36,788	111,468,000
Circular Saw (Cold)	385	110	30,067	91,419,000
Abrasive Wheel	757	105	32,419	147,229,000
Bandsaw	819	97	86,405	256,991,000
Other	905A	107	9,842	29,215,000

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Boring Machines

Number of Machines in Class: 20,773

Average Enclosure Area, ft^2: 332

Average Enclosure Cost, $: 3,111

Mean Noise Level, dBA: --

Total Enclosure Cost for Machine Class, $: 43,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Internal	332	-	18,617	39,319,000
External	332A	-	2,109	4,448,000

Table A.8

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Logging Machines

Number of Machines in Class: 13,320

Average Enclosure Area, ft^2: 381

Average Enclosure Cost, $: 2,291

Mean Noise Level, dBA: --

Total Enclosure Cost for Machine Class, $: 30,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Flat Surface	293	-	7,783	18,484,000
Cylindrical	464	-	3,710	7,656,000
Other	381A	-	1,787	6,180,000

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Polishing and Buffing Machines

Number of Machines in Class: 110,210

Average Enclosure Area, ft^2: 185

Average Enclosure Cost, $: 1,110

Mean Noise Level, dBA: 93

Total Enclosure Cost for Machine Class, $: 122,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Polishing Stands	185	-	62,997	69,927,000
Abrasive Belt, Disk, Drum	185A	-	37,333	41,440,000
Other	185A	-	9,886	10,973,000

Table A.8

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Gear Cutting and Finishing Machines

Number of Machines in Class: 41,387

Average Enclosure Area, ft^2: 320

Average Enclosure Cost, $: 3,120

Mean Noise Level, dBA: 84

Total Enclosure Cost for Machine Class, $: 129,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Gear Hobbers	329	=	17,876	56,738,000
Gear Shapers	497	84	9,493	28,308,000
Form-Milling Type	474	=	1,645	4,678,000
Bevel-Gear Cutters	650	=	3,303	9,762,000
Gear-Tooth Finishers	487	=	5,289	15,454,000
Other	320A	=	4,581	14,293,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Electrical Machining Units

Number of Machines in Class: 11,176

Average Enclosure Area, ft^2: 387

Average Enclosure Cost, $: $3,334

Mean Noise Level, dBA: --

Total Enclosure Cost for Machine Class, $: 36,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Electrical-Discharge Machines (EDM)	329	-	9,145	18,052,000
Electrochemical Machines (ECM)	857	-	1,183	6,083,000
Electrolytic Grinders (ELG or ECG)	383	-	848	1,949,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Other Metalcutting Machines

Number of Machines in Class: 15,659

Average Enclosure Area, ft^2: 503A

Average Enclosure Cost, $: 3,012

Mean Noise Level, dBA: 88

Total Enclosure Cost for Machine Class, $: 47,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Bending and Forming Machines - Power

Number of Machines in Class: 98,311

Average Enclosure Area, ft^2: 1,342

Average Enclosure Cost, $: 8,032

Mean Noise Level, dBA: 103

Total Enclosure Cost for Machine Class, $: 789,930,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Bending Rolls, Sheet and Plate	900	93	21,074	63,233,000
Bending Rolls, Bar, Shapes and Pipe	461	-	8,645	27,912,000
Bending Brakes and Folders	1342A	-	11,151	89,788,000
Press Brakes, Mechanical	1739	111	38,201	398,589,000
Press Brakes, Hydraulic and Pneumatic	2430	111	9,347	136,279,000
Rotary Bending and Forming Machines	1342A	-	9,893	79,658,000

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Hydraulic and Pneumatic Presses (Except Forging)

Number of Machines in Class: 76,799

Average Enclosure Area, ft^2: 634

Average Enclosure Cost, $: 3,924

Mean Noise Level, dBA: 101

Total Enclosure Cost for Machine Class, $: 301,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Vertical, Single Action	635	-	51,426	192,848,000
Vertical, Double and Triple Action	1143	-	3,602	38,419,000
Horizontal, Single Action	353	-	4,158	8,807,000
Pneumatic Presser	654A	-	10,954	42,983,000
Other	654A	-	4,659	18,383,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Mechanical Presses-Power (Except Forging)

Number of Machines in Class: 290,979

Average Enclosure Area, ft^2: 761

Average Enclosure Cost, $: 4,366

Mean Noise Level, dBA: 99

Total Enclosure Cost for Machine Class, $: 1,329,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Inclinable, Single Action	933	-	156,760	896,334,000
Gap or C-Frame	516	-	56,788	175,816,000
Straight Side, Single Action	365	-	47,351	103,699,000
Straight Side, Double- and Triple-Action	1143	-	6,245	42,828,000
Knuckle-Joint	736	-	1,996	8,814,000
Adjustable Bed and Horning	329	-	6,207	12,253,000
Pull Down Punching and Stamping	732	-	5,569	24,459,000
Multiple Transfer, Automatic	1569	-	3,624	34,551,000
Multiple Plunger	761A	-	3,981	18,177,000
Horizontal	761A	-	9,458	11,323,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Punching and Shearing Machines - Power

Number of Machines in Class: 89,038

Average Enclosure Area, ft^2: 613

Average Enclosure Cost, $: 3,673

Mean Noise Level, dBA: 105

Total Enclosure Cost for Machine Class, $: 327,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Punching, Fixed Position	442	-	30,491	34,342,000
Punching, Two-Axis Positioning Table, Single-Station	613A	-	2,864	10,517,000
Punching, Two-Axis Positioning Table, Turret	613A	-	2,575	9,455,000
Plate and Sheet Shears, Mechanical	702	105	35,112	147,893,000
Plate and Sheet Shears, Hydraulic	702	105	3,611	15,210,000
Bar and Angle Shears	613A	105	7,917	29,071,000
Rotary Shears	613A	105	5,024	18,448,000
Combination Machine	613A	-	6,186	72,715,000
Other	613A	-	5,248	19,271,000

Table A.8

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Forging Machines

Number of Machines in Class: 37,747

Average Enclosure Area, ft^2: 1,347

Average Enclosure Cost, $: 9,282

Mean Noise Level, dBA: 108

Total Enclosure Cost for Machine Class, $: 338,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Presses, Mechanical	3565	103	4,588	98,137,000
Presses, Hydraulic	7972	103	1,356	54,860,000
Hammers, Single-Action	977	114	3,993	35,125,000
Hammers, Double-Action	764	114	316	1,449,000
Headers, Hot or Cold	815	102	10,713	39,527,000
Rolls and Swagers	493	112	4,105	12,143,000
Other	1547A	-	678	6,293,000

Table A.3

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Cleaning and Finishing Equipment

Number of Machines in Class: 166,013

Average Enclosure Area, ft^2: 1,201

Average Enclosure Cost, $: 7,206

Mean Noise Level, dBA: 101

Total Enclosure Cost for Machine Class, $: 1,052,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Barrel Finishing Machines	538	101	30,561	98,631,000
Vibratory Finishing Machines	517	"	12,794	39,687,000
Shot, Abrasive and Other Blast Units	820	"	26,375	129,765,00
Parts - Washing Machines	469	"	43,337	121,950,000
Plating Machines	8136	"	12,851	627,334,000
Plating Barrels	1201A	"	20,095	144,805,000

Table A.3

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Plastics-Molding and Diecasting Machines

Number of Machines in Class: (11,219) 45,172[a]

Average Enclosure Area, ft^2: 909

Average Enclosure Cost, $: 5,034

Mean Noise Level, dBA: 80

Total Enclosure Cost for Machine Class, $: $1,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Plastics-Molding Machines, Injection[a]	336	-	20,870	69,622,000[a]
Plastics-Molding Machines, Compression[a]	1787	-	13,083	140,276,000[a]
Diecasting Machines (Hot and Cold Chamber)	909	80	11,219	61,188,000

[a]Not included in fabricated metal products industry.

Table A.1

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Other Joining Equipment
Number of Machines in Class: 31,030
Average Enclosure Area, ft^2: 606
Average Enclosure Cost, $: 3,636
Mean Noise Level, dBA: 97
Total Enclosure Cost for Machine Class, $: 113,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Gas Welding or Brazing Machines	606A	-	5,861	21,311,000
Flame Cutting Machines	637	92	14,859	56,791,000
Metallising Equipment	410	102	4,717	14,434,000
Brazing Machines (Induction and Resistance)	606A	-	5,593	20,336,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Electric Resistance Welding Equipment
Number of Machines in Class: 103,932
Average Enclosure Area, ft^2: 466
Average Enclosure Cost, $: 2,676
Mean Noise Level, dBA: 96
Total Enclosure Cost for Machine Class, $: 278,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Spot	464	=	73,835	205,557,000
Projection	446A	=	11,733	31,398,000
Seam	530	=	4,445	14,295,000
Butt and Flash	306	=	7,180	8,874,000
Portable Gun Type (Not Hand)	446A	=	6,759	18,087,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Electric Arcwelding Equipment

Number of Machines in Class: 363,030

Average Enclosure Area, ft^2: 371

Average Enclosure Cost, $: 1,621

Mean Noise Level, dBA: 97

Total Enclosure Cost for Machine Class, $: 590,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Manual Welding Equipment, Generator Type	319	97	103,398	196,373,000
Manual Welding Equipment, Transformer Type	106	"	103,414	126,584,000
Manual Welding Equipment, Rectifier Type	228	"	66,261	120,768,000
Semiautomatic Machines	373	"	33,079	90,333,000
Automatic Machines	645	"	14,648	56,666,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Other Metalforming Machines

Number of Machines in Class: 38,747

Average Enclosure Area, ft^2: 483

Average Enclosure Cost, $: 2,898

Mean Noise Level, dBA: 89

Total Enclosure Cost for Machine Class, $: 112,001,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Thread-Rolling Machines	672	89	8,663	33,326,000
Marking Machines	483A	-	7,899	22,891,000
Roll-Forming Machines	426	-	12,255	31,324,000
Other	412	-	9,930	24,596,000

Table A.2

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Riveting Machines

Number of Machines in Class: 55,391

Average Enclosure Area, ft^2: 325

Average Enclosure Cost, $: 1,950

Mean Noise Level, dBA: 118

Total Enclosure Cost for Machine Class, $: 108,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Squeeze Type	325	-	38,356	74,794,000
Other	325A	115	16,991	33,140,000

Table A.8

ENCLOSURE/NOISE LEVEL/ENCLOSURE COSTS SUMMARY

Machine Class: Wire and Metal Ribbon Formers

Number of Machines in Class: 26,315

Average Enclosure Area, ft^2: 964

Average Enclosure Cost, $: 3,784

Mean Noise Level, dBA: 98

Total Enclosure Cost for Machine Class, $: 132,000,000

Machine Type	Average Enclosure Surface Area (ft^2)	Mean Noise Level (dBA)	Number of Machines in Industry	Enclosure Costs for Machines ($)
Press Type, Single or Double Slide	964	101	13,076	75,632,000
Other	964A	95	13,239	76,574,000

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Turning Machines
Number of Machines in Class: 493,447
Average $ Machine Cost, $: 1,972
Mean Noise Level, dBA: 91
Total $ Machine Cost for Machine Class, $: 973,246,000

Machine Type		Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Bench Lathes		1,000	-	61,993	61,993,000
Engine and Toolroom Lathes	<9 inch swing	1,000	89	31,305	31,305,000
	9 to 16 inch swing	1,500	89	49,226	148,839,000
	17 to 33 inch swing	2,000	89	41,773	83,546,000
	334 inch swing	3,500	89	19,090	66,815,000
Tracer Lathes		2,000	88	14,918	29,836,000
Turret Lathes, Ram Type		1,500	93	44,908	67,362,000
Turret Lathes, Saddle Type		1,500	93	28,229	42,344,000
Automatic Chucking, Single Spindle		2,500	90	21,574	53,935,000
Automatic Chucking, Multispindle		5,000	90	10,588	52,940,000
Automatic Between Centers Chucking		2,500	90	6,189	15,473,000
Automatic Bar Machines, Single Spindle		2,500	93	47,375	118,438,000
Automatic Bar Machines, Multispindle		2,500	93	33,695	84,238,000

Table 5.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Turning Machines (Concl)
Number of Machines in Class:
Average $ Machine Cost, $:
Mean Noise Level, dBA:
Total $ Machine Cost for Machine Class, $:

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Vertical Turning and Boring Mills	5,000	93	19,216	96,080,000
Other Lathes	1,500	"	13,468	20,202,000

Table B.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Boring Machines
Number of Machines in Class: 34,166
Average A Machine Cost, $: 6,331
Mean Noise Level, dBA: 94E
Total A Machine Cost for Machine Class, $: 334,393,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Horizontal Bore, Drill, Mill, Table and Planer Type	5,000	-	11,234	56,170,000
Horizontal Bore, Drill, Mill, Floor Type	5,000	-	11,605	58,025,000
Precision	2,500	-	14,495	36,238,000
Jig Borers	5,000	-	14,598	72,990,000
Other	5,000	-	2,234	11,170,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Drilling Machines
Number of Machines in Class: 433,715
Average A Machine Cost, $: 1,196
Mean Noise Level, dBA: 85E
Total A Machine Cost for Machine Class, $: 343,098,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Sensitive, Bench	1,000	E	98,253	98,253,000
Sensitive, Floor and Pedestal	1,000	E	85,347	85,347,000
Upright, Single Spindle	1,000	E	139,487	139,487,000
Upright, Gang	1,500	E	40,977	61,466,000
Upright, Turret	1,500	E	9,783	14,673,000
Radial	1,500	E	44,653	66,978,000
Multispindle Cluster	2,500	E	23,068	57,670,000
Deep Hole	1,500	E	5,648	8,472,000
Other	1,500	E	8,501	12,752,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Milling Machines
Number of Machines in Class: 288,139
Average $ Machine Cost, $: 2,200
Mean Noise Level, dBA: 96E
Total $ Machine Cost for Machine Class, $: 633,808,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Bench Type	1,000	-	16,956	16,956,000
Hand	1,000	-	19,437	19,437,000
Vertical, Ram Type	1,300	-	57,436	86,184,000
General Purpose, Knee or Bed, Horizontal	2,000	-	70,810	141,620,000
General Purpose, Knee or Bed, Vertical	3,000	-	66,560	199,680,000
Manufacturing, Knee or Bed	3,000	-	20,309	60,927,000
Planer Type	3,500	-	4,592	16,072,000
Profiling and Duplicating	3,000	-	17,401	52,203,000
Thread Mills	3,500	-	4,163	14,571,000
Other	2,900	-	10,455	30,130,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Multifunction Machines

Number of Machines in Class: 14,738

Average $ Machine Cost, $: 4,432

Mean Noise Level, dBA: 94E

Total $ Machine Cost for Machine Class, $: 65,369,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Drill-Mill-Bore, Manual Toolchange	3,500	-	7,176	25,116,000
Drill-Mill-Bore, Indexing Turret	3,500	-	3,546	12,411,000
Drill-Mill-Bore, Automatic Toolchange, Vertical	7,000	-	1,855	12,985,000
Drill-Mill-Bore, Automatic Toolchange, Horizontal	7,000	-	2,151	15,057,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Special Way-Type and Transfer Machines
Number of Machines in Class: 14,834
Average $ Machine Cost, $: 10,000
Mean Noise Level, dBA: 94E
Total $ Machine Cost for Machine Class, $: 143,340,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs For Machines ($)
Single Station	10,000	=	3,921	39,230,000
Multistation, Rotary Transfer	10,000	=	5,846	58,460,000
Multistation, In-Line Transfer	10,000	=	5,083	50,850,000

E = Estimated Noise Level

Table 8.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Automatic Assembly, Tapping and Threading Machines

Number of Machines in Class: 69,373

Average A Machine Cost, $: 3,994

Mean Noise Level, dBA: 92

Total A Machine Cost for Machine Class, $: 277,070,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Automatic Assembly Machines	10,000	-	17,390	173,900,000
Tapping Machines	2,000	94	36,340	72,680,000
Threading Machines	2,000	89	15,745	31,490,000

Table B.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Broaching Machines
Number of Machines in Class: 14,420
Average A Machine Cost, $: 3,500
Mean Noise Level, dBA: 91E
Total A Machine Cost for Machine Class, $: 31,171,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Internal	3,500	E	9,499	33,247,000
Surface and Other	3,500	E	5,121	17,924,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Planing Machines

Number of Machines in Class: 7,613

Average $ Machine Cost, $: 5,000

Mean Noise Level, dBA: 110E

Total $ Machine Cost for Machine Class, $: 38,060,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Double Column	5,000	=	4,573	22,865,000
Openside and Other	5,000	=	3,039	15,195,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Shaping Machines

Number of Machines in Class: 28,343

Average $ Machine Cost, $: 2,500

Mean Noise Level, dBA: 99E

Total $ Machine Cost for Machine Class, $: 71,363,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Horizontal	2,500	-	22,139	55,398,000
Vertical	2,500	-	6,386	15,965,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Cutoff, Saws and Filing Machines
Number of Machines in Class: 218,901
Average $ Machine Cost, $: 1,387
Mean Noise Level, dBA: 104
Total $ Machine Cost for Machine Class, $: 347,470,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Contour Saws	1,500	97	23,584	35,376,000
Hacksaw	2,000	107	36,788	73,576,000
Circular Saw (Cold)	3,500	110	30,067	105,235,000
Abrasive Wheel	1,000	105	32,415	32,415,000
Bandsaw	1,000	97	88,409	88,409,000
Other	1,500	107	9,642	14,463,000

Table 8.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Grinding Machines

Number of Machines in Class: 489,600

Average A Machine Cost, $: 1,593

Mean Noise Level, dBA: 93

Total A Machine Cost for Machine Class, $: 780,029,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
External, Plain Center Type	3,000	-	32,051	96,153,000
External, Universal Center Type	3,000	-	18,363	55,089,000
External, Centerless	3,000	-	20,104	60,312,000
External, Chucking	3,000	-	3,286	9,858,000
Internal	3,000	-	18,089	54,267,000
Surface, Rotary Table	3,000	-	35,468	106,404,000
Surface, Reciprocating	1,500	-	67,204	100,806,000
Disk Grinders	1,000	-	44,813	44,813,000
Abrasive Belt	1,000	-	47,823	47,823,000
Contour Grinders	1,500	-	4,130	6,195,000
Thread Grinders	1,000	-	5,773	5,773,000
Tool and Cutter Grinders	1,000	98	64,781	64,781,000
Bench, Floor and Snag	1,000	100	105,854	105,854,000
Other (including Jig Grinders)	1,000	90	31,841	31,841,000

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Honing Machines

Number of Machines in Class: 20,723

Average $ Machine Cost, $: 1,500

Mean Noise Level, dBA: 95E

Total $ Machine Cost for Machine Class, $: 31,085,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Internal	1,500	-	18,617	27,926,000
External	1,500	-	2,106	3,159,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COST: SUMMARY

Machine Class: Lapping Machines

Number of Machines in Class: 13,320

Average $ Machine Cost, $: 1,500

Mean Noise Level, dBA: 93E

Total $ Machine Cost for Machine Class, $: 19,981,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Flat Surface	1,500	-	7,783	11,675,000
Cylindrical	1,500	-	2,750	4,125,000
Other	1,500	-	2,787	4,181,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Polishing and Buffing Machines

Number of Machines in Class: 110,216

Average $ Machine Cost, $: 1,102

Mean Noise Level, dBA: 93E

Total $ Machine Cost for Machine Class, $: 121,469,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Polishing Stands	1,000	=	62,997	62,997,000
Abrasive Belt, Disk, Drum	1,500	=	37,333	56,000,000
Other	250	=	9,886	2,472,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Gear Cutting and Finishing Machines

Number of Machines in Class: 41,387

Average A Machine Cost, $: 2,000

Mean Noise Level, dBA: 84

Total A Machine Cost for Machine Class, $: 82,774,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Gear Hobbers	2,000	=	17,876	35,752,000
Gear Shapers	2,000	84	9,493	18,986,000
Form-Milling Type	2,000	=	1,645	3,290,000
Bevel Gear Cutters	2,000	=	2,503	5,006,000
Gear-Tooth Finishers	2,000	=	5,289	10,578,000
Other	2,000	=	4,581	9,162,000

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Electrical Machining Units

Number of Machines in Class: 11,176

Average $ Machine Cost, $: 2,000

Mean Noise Level, dBA: 85E

Total $ Machine Cost for Machine Class, $: 22,352,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Electrical Discharge Machines (EDM)	2,000	-	9,145	18,290,000
Electrochemical Machines (ECM)	2,000	-	1,183	2,366,000
Electrolytic Grinders (ELG or ECG)	2,000	-	848	1,696,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Other Metalcutting Machines

Number of Machines in Class: 15,659

Average $ Machine Cost, $: 1,500

Mean Noise Level, dBA: 93E

Total $ Machine Cost for Machine Class, $: 23,489,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Bending and Forming Machines - Power

Number of Machines in Class: 98,311

Average $ Machine Cost, $: 1,564

Mean Noise Level, dBA: 105

Total $ Machine Cost for Machine Class, $: 151,791,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Bending Rolls, Sheet and Plate	1,500	92	21,074	31,611,000
Bending Rolls, Bar, Shapes and Pipe	2,000	-	8,645	17,290,000
Bending Brakes and Folders	1,500	-	11,151	16,727,000
Press Brakes, Mechanical	1,500	111	38,201	57,302,000
Press Brakes, Hydraulic and Pneumatic	1,500	111	9,347	14,021,000
Rotary Bending and Forming Machines	1,500	-	9,893	14,840,000

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Hydraulic and Pneumatic Presses (except Forging)

Number of Machines in Class: 76,799

Average $ Machine Cost, $: 2,369

Mean Noise Level, dBA: 101E

Total $ Machine Cost for Machine Class, $: 181,932,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Vertical, Single Action	2,500	-	51,426	128,568,000
Vertical, Double and Triple Action	2,500	-	5,602	14,005,000
Horizontal, Single Action	2,000	-	4,158	8,316,000
Pneumatic Presses	2,000	-	10,954	21,908,000
Other	2,000	-	4,659	9,138,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Mechanical Presses - Power (except Forging)

Number of Machines in Class: 290,979

Average $ Machine Cost, $: 2,766

Mean Noise Level, dBA: 99E

Total $ Machine Cost for Machine Class, $: 804,722,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Inclinable, Single Action	1,500	E	156,760	235,140,000
Gap or C-Frame	2,000	E	56,788	113,576,000
Straight Side, Single Action	6,000	E	47,351	279,371,000
Straight Side, Double or Triple Action	10,000	E	6,245	62,450,000
Knuckle-Joint	2,500	E	1,996	4,990,000
Adjustable Bed and Horning	5,000	E	6,207	31,035,000
Pull-Down Punching and Stamping	5,000	E	5,569	27,845,000
Multiple Transfer, Automatic	5,000	E	3,624	18,120,000
Multiple Plunger	5,000	E	3,981	19,905,000
Horizontal	5,000	E	2,458	12,290,000

E = Estimated Noise Level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Punching and Shearing Machines - Power

Number of Machines in Class: 89,028

Average $ Machine Cost, $: 2,702

Mean Noise Level, dBA: 105

Total $ Machine Cost for Machine Class, $: 240,554,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Punching, Fixed Position	3,000	-	20,491	61,473,000
Punching, Two-Axis Positioning Table, Single Station	3,000	-	2,864	8,592,000
Punching, Two-Axis Positioning Table, Turret	3,000	-	2,575	7,725,000
Plate and Sheet Shears, Mechanical	3,000	105	35,112	105,336,000
Plate and Sheet Shears, Hydraulic	3,000	105	3,611	10,833,000
Bar and Angle Shears	2,000	105	7,917	15,834,000
Rotary Shears	2,000	105	5,024	10,048,000
Combination Machine	2,500	-	6,186	15,465,000
Other	1,000	-	5,248	5,248,000

Table B.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Forging Machines
Number of Machines in Class: 37,747
Average A Machine Cost, $: 8,398
Mean Noise Level, dBA: 108
Total A Machine Cost for Machine Class, $: 333,018,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Presses, Mechanical	10,000	103	4,588	45,880,000
Presses, Hydraulic	10,000	103	1,356	13,560,000
Hammers, Single-Action	10,000	114	3,992	39,920,000
Hammers, Double-Action	10,000	114	316	3,160,000
Headers, Hot or Cold	7,000	102	10,712	74,984,000
Rolls and Swagers	7,000	112	4,105	28,735,000
Other	10,000	-	678	6,780,000

Table B.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Wire and Metal-Ribbon Formers

Number of Machines in Class: 26,313

Average A Machine Cost, $: 5,000

Mean Noise Level, dBA: 98

Total A Machine Cost for Machine Class, $: 131,575,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Press Type, Single or Multiple Slide	5,000	101	13,076	65,380,000
Other	5,000	95	13,239	66,195,000

Table B.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Riveting Machines

Number of Machines in Class: 55,351

Average A Machine Cost, $: 2,000

Mean Noise Level, dBA: 118

Total A Machine Cost for Machine Class, $: 110,702,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Squeeze Type	2,000	-	38,336	76,712,000
Other	2,000	118	16,995	33,990,000

Table 8.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Other Metal Forming Machines

Number of Machines in Class: 38,767

Average A Machine Cost, $: 2,000

Mean Noise Level, dBA: 89

Total A Machine Cost for Machine Class, $: 77,534,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Thread Rolling Machines	2,000	89	8,663	17,326,000
Marking Machines	2,000	-	7,899	15,798,000
Roll-Forming Machines	2,000	-	12,255	24,510,000
Other	2,000	-	9,950	19,900,000

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Electric Arcwelding Equipment

Number of Machines in Class: 363,020

Average $ Machine Cost, $: 400

Mean Noise Level, dBA: 97

Total $ Machine Cost for Machine Class, $: 145,208,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Manual Welding Equipment, Generator Type	400	97	102,598	41,039,000
Manual Welding Equipment, Transformer Type	400	-	102,414	40,966,000
Manual Welding Equipment, Rectifier Type	400	-	88,281	35,312,000
Semiautomatic Machines	400	-	55,079	22,032,000
Automatic Machines	400	-	14,648	5,859,000

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Electric Resistance Welding Equipment

Number of Machines in Class: 103,952

Average $ Machine Cost, $: 1,503

Mean Noise Level, dBA: 94E

Total $ Machine Cost for Machine Class, $: 156,230,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Spot	1,000	E	73,835	73,835,000
Projection	3,000	E	11,733	39,333,000
Seam	5,000	E	4,445	22,225,000
Butt and Flash	1,000	E	7,180	7,180,000
Portable Gun Type (Hot Hand)	3,500	E	6,759	23,657,000

E = Estimated noise level

Table B.1

MACHINE/NOISE LEVEL/$ MACHINE COSTS SUMMARY

Machine Class: Other Joining Equipment

Number of Machines in Class: 31,030

Average $ Machine Cost, $: 1,000

Mean Noise Level, dBA: 97

Total $ Machine Cost for Machine Class, $: 31,030,000

Machine Type	Average $ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	$ Machine Costs for Machines ($)
Gas Welding or Brazing Machines	1,000	-	5,861	5,861,000
Flame Cutting Machines	1,000	97	14,859	14,859,000
Heatlizing Equipment	1,000	103	4,717	4,717,000
Brazing Machines (Induction and Resistance)	1,000	-	5,593	5,593,000

Table B.1

MACHINE/NOISE LEVEL/Δ MACHINE COSTS SUMMARY

Machine Class: Plastics Molding and Diecasting Machines
Number of Machines in Class: 11,219
Average Δ Machine Cost, $: 0
Mean Noise Level, dBA: 80
Total Δ Machine Cost for Machine Class, $:

Machine Type	Average Δ Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	Δ Machine Costs for Machines ($)
Plastics Molding Machines, Injection*		-	20,870	
Plastics Molding Machines, Compression*		-	13,083	
Diecasting Machines (Hot and Cold Chambers)	0	80	11,219	0

* Not included in fabricated metal products industry

Table 9.1

MACHINE/NOISE LEVEL/A MACHINE COSTS SUMMARY

Machine Class: Cleaning and Finishing Equipment
Number of Machines in Class: 146,013
Average A Machine Cost, $: 2,500
Mean Noise Level, dBA: 101
Total A Machine Cost for Machine Class, $: 365,033,000

Machine Type	Average A Machine Cost ($)	Mean Noise Level (dBA)	Number of Machines in Industry	A Machine Costs for Machines ($)
Barrel Finishing Machines	2,500	101	30,561	76,403,000
Vibratory Finishing Machines	2,500	-	12,794	31,985,000
Shot Abrasive and Other Blast Units	2,500	-	26,375	65,938,000
Parts-Washing Machines	2,500	-	43,337	108,343,000
Plating Machines	2,500	-	12,851	32,128,000
Plating Barrels	2,500	-	20,095	50,238,000